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<b>(21) International Application Number:</b> PCT/CA96/00605 <b>(22) International Filing Date:</b> 12 September 1996 (12.09.96) <b>(30) Priority Data:</b> 08/532,896 22 September 1995 (22.09.95) US <b>(71) Applicant (for all designated States except US):</b> EN-DORECHERCHE INC. [CA/CA]; 2989 de la Promenade, Ste-Foy, Québec G1W 2J5 (CA). <b>(72) Inventors; and</b> <b>(75) Inventors/Applicants (for US only):</b> LABRIE, Fernand [CA/CA]; 2989 de la Promenade, Ste-Foy, Québec G1W 2J5 (CA). LUU-THE, Van [CA/CA]; 4460 rue de l'Estuaire, Charny, Québec G6X 1C6 (CA). <b>(74) Agent:</b> MITCHELL, Richard, J.; Marks & Clerk, P.O. Box 957, Station B, Ottawa, Ontario K1P 5S7 (CA).		<b>(81) Designated States:</b> AL, AM, AT, AU, AZ, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, US, UZ, VN, ARIPO patent (KE, LS, MW, SD, SZ, UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).  <b>Published</b> With international search report.
<b>(54) Title:</b> PRODUCTION AND USE OF TYPE 5 17BETA-HYDROXYSTEROID DEHYDROGENASE  <b>(57) Abstract</b>  A novel type 5 17 $\beta$ -hydroxysteroid dehydrogenase is provided. Methods of producing the enzyme and using the enzyme to identify potential compounds which inhibit or alter the activity of the enzyme are described. In addition, methods of using the gene sequence or portions thereof for probes or to produce expression-disrupting sense or antisense DNA fragments thereof, or antisense RNA, are provided.		

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## PRODUCTION AND USE OF TYPE 5 17BETA-HYDROXYSTEROID DEHYDROGENASE

## BACKGROUND OF THE INVENTION

*Field of the Invention*

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The present invention relates to the isolation and characterization of a novel enzyme which is implicated in the production of sex steroids, and more particularly, to the characterization of the gene and cDNA of a novel  $20\alpha$ ,  $17\beta$ -hydroxysteroid dehydrogenase (hereinafter type 5  $17\beta$ -HSD) which has been implicated in the conversion of progesterone and 4-androstenedione ( $\Delta^4$ -dione) to  $20\alpha$ -hydroxyprogesterone ( $20\alpha$ -OH-P) and testosterone (T), respectively. The use of this enzyme as an assay for inhibitors of the enzyme is also described, as are several other uses of the DNA, fragments thereof and antisense fragments thereof.

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*Description of the Related Art*

The enzymes identified as  $17\beta$ -HSDs are important in the production of human sex steroids, including androst-5-ene- $3\beta$ , $17\beta$ -diol ( $\Delta^5$ -diol), testosterone and estradiol. It was once thought that a single gene encoded a single type of  $17\beta$ -HSD which was responsible for catalyzing all of the reactions. However, in humans, several types of  $17\beta$ -HSD have now been identified and characterized. Each type of  $17\beta$ -HSD has been found to catalyze specific reactions and to be located in specific tissues. Further information about Types 1, 2 and 3  $17\beta$ -HSD can be had by reference as follows: Type 1  $17\beta$ -HSD is described by Luu-The, V. et al., *Mol. Endocrinol.*, 3:1301-1309 (1989) and by Peltoketo, H. et al., *FEBS Lett*, 239:73-77 (1988); Type 2  $17\beta$ -HSD is described in Wu, L. et al., *J. Biol Chem*, 268:12964-12969 (1993); Type 3  $17\beta$ -HSD is described in Geissler, WM, *Nature Genetics*, 7:34-39 (1994). A fourth type which is homologous to porcine ovarian  $17\beta$ -HSD has recently been identified by researchers Adamski and de Launoit, however, applicant is not presently aware of published information on this type.

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The present invention relates to a fifth type of  $17\beta$ -HSD which is described in detail below.

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## SUMMARY OF THE INVENTION

It is an object of the present invention to provide a novel 17 $\beta$ -hydroxysteroid dehydrogenase (17 $\beta$ -HSD) which is identified as type 5 17 $\beta$ -HSD.

It is also an object of the present invention to provide a 17 $\beta$ -HSD which has been shown to be involved in the conversion of  $\Delta^4$ -dione to testosterone and in the conversion of progesterone to 20 $\alpha$ -hydroxyprogesterone (20 $\alpha$ -OH-P).

It is a further object of this invention to provide the nucleotide sequences and a gene map for type 5 17 $\beta$ -HSD.

It is also an object of this invention to provide methods of using type 5 17 $\beta$ -HSD in an assay to identify compounds which inhibit the activity of this enzyme, and thus may reduce production of testosterone or 20 $\alpha$ -hydroxyprogesterone, and can be used to treat medical conditions which respond unfavorably to these steroids.

It is an additional object of this invention to provide methods of preventing the synthesis of type 5 17 $\beta$ -HSD by administering an antisense RNA of the gene sequence of type 5 17 $\beta$ -HSD to interfere with the translation of the gene's mRNA.

These and other objects are discussed herein.

In particular, a novel enzyme, type 5 17 $\beta$ -hydroxysteroid dehydrogenase, has been identified and characterized. The gene sequence for this type 5 17 $\beta$ -HSD was found to encode a protein of 323 amino acids, having an apparent calculated molecular weight of 36,844 daltons. The protein is encoded by nucleotides +11 through 982, including the stop codon (amino acids +1 through 323), numbered in the 5' to 3' direction, in the following sequence (SEQ ID Nos. 1 and 2):

GTGACAGGGA ATG GAT TCC AAA CAG CAG TGT GTA AAG CTA AAT GAT GGC 49  
Met Asp Ser Lys Gln Gln Cys Val Lys Leu Asn Asp Gly  
1 5 10

CAC TTC ATG CCT GTA TTG GGA TTT GGC ACC TAT GCA CCT CCA GAG GTT 97  
His Phe Met Pro Val Leu Gly Phe Gly Thr Tyr Ala Pro Pro Glu Val  
15 20 25

CCG AGA AGT AAA GCT TTG GAG GTC ACC AAA TTA GCA ATA GAA GCT GGG 145  
Pro Arg Ser Lys Ala Leu Glu Val Thr Lys Leu Ala Ile Glu Ala Gly  
30 35 40 45

TTC CGC CAT ATA GAT TCT GCT CAT TTA TAC AAT AAT GAG GAG CAG GTT 193

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Phe Arg His Ile Asp Ser Ala His Leu Tyr Asn Asn Glu Glu Gln Val  
 50 55 60

5 GGA CTG GCC ATC CGA AGC AAG ATT GCA GAT GGC AGT GTG AAG AGA GAA 241  
 Gly Leu Ala Ile Arg Ser Lys Ile Ala Asp Gly Ser Val Lys Arg Glu  
 65 70 75

10 GAC ATA TTC TAC ACT TCA AAG CTT TGG TCC ACT TTT CAT CGA CCA GAG 289  
 Asp Ile Phe Tyr Thr Ser Lys Leu Trp Ser Thr Phe His Arg Pro Glu  
 80 85 90

15 TTG GTC CGA CCA GCC TTG GAA AAC TCA CTG AAA AAA GCT CAA TTG GAC 337  
 Leu Val Arg Pro Ala Leu Glu Asn Ser Leu Lys Lys Ala Gln Leu Asp  
 95 100 105

TAT GTT GAC CTC TAT CTT ATT CAT TCT CCA ATG TCT CTA AAG CCA GGT 385  
 Tyr Val Asp Leu Tyr Leu Ile His Ser Pro Met Ser Leu Lys Pro Gly  
 110 115 120 125

20 GAG GAA CTT TCA CCA ACA GAT GAA AAT GGA AAA GTA ATA TTT GAC ATA 433  
 Glu Glu Leu Ser Pro Thr Asp Glu Asn Gly Lys Val Ile Phe Asp Ile  
 130 135 140

25 GTG GAT CTC TGT ACC ACC TGG GAG GCC ATG GAG AAG TGT AAG GAT GCA 481  
 Val Asp Leu Cys Thr Thr Trp Glu Ala Met Glu Lys Cys Lys Asp Ala  
 145 150 155

30 GGA TTG GCC AAG TCC ATT GGG GTG TCA AAC TTC AAC CGC AGG CAG CTG 529  
 Gly Leu Ala Lys Ser Ile Gly Val Ser Asn Phe Asn Arg Arg Gln Leu  
 160 165 170

35 GAG ATG ATC CTC AAC AAG CCA GGA CTC AAG TAC AAG CCT GTC TGC AAC 577  
 Glu Met Ile Leu Asn Lys Pro Gly Leu Lys Tyr Lys Pro Val Cys Asn  
 175 180 185

CAG GTA GAA TGT CAT CCG TAT TTC AAC CGG AGT AAA TTG CTA GAT TTC 625  
 Gln Val Glu Cys His Pro Tyr Phe Asn Arg Ser Lys Leu Leu Asp Phe  
 190 195 200 205

40 TGC AAG TCG AAA GAT ATT GTT CTG GTT GCC TAT AGT GCT CTG GGA TCT 673  
 Cys Lys Ser Lys Asp Ile Val Leu Val Ala Tyr Ser Ala Leu Gly Ser  
 210 215 220

45 CAA CGA GAC AAA CGA TGG GTG GAC CCG AAC TCC CCG GTG CTC TTG GAG 721  
 Gln Arg Asp Lys Arg Trp Val Asp Pro Asn Ser Pro Val Leu Leu Glu  
 225 230 235

50 GAC CCA GTC CTT TGT GCC TTG GCA AAA AAG CAC AAG CGA ACC CCA GCC 769  
 Asp Pro Val Leu Cys Ala Leu Ala Lys Lys His Lys Arg Thr Pro Ala  
 240 245 250

55 CTG ATT GCC CTG CGC TAC CAG CTG CAG CGT GGG GTT GTG GTC CTG GCC 817  
 Leu Ile Ala Leu Arg Tyr Gln Leu Gln Arg Gly Val Val Val Leu Ala  
 255 260 265

AAG AGC TAC AAT GAG CAG CGC ATC AGA CAG AAC GTG CAG GTT TTT GAG 865  
 Lys Ser Tyr Asn Glu Gln Arg Ile Arg Gln Asn Val Gln Val Phe Glu  
 270 275 280 285

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TTC CAG TTG ACT GCA GAG GAC ATG AAA GCC ATA GAT GGC CTA GAC AGA 913  
 Phe Gln Leu Thr Ala Glu Asp Met Lys Ala Ile Asp Gly Leu Asp Arg  
 290 295 300  
 5 AAT CTC CAC TAT TTT AAC AGT GAT AGT TTT GCT AGC CAC CCT AAT TAT 961  
 Asn Leu His Tyr Phe Asn Ser Asp Ser Phe Ala Ser His Pro Asn Tyr  
 305 310 315  
 10 CCA TAT TCA GAT GAA TAT TAA CATGGAGACT TTGCCTGATG ATGTCTACCA 1012  
 Pro Tyr Ser Asp Glu Tyr \*  
 320  
 15 GAAGGCCCTG TGTGTGGATG GTGACGCAGA GGACGTCTCT ATGCCGGTGA CTGGACATAT 1072  
 CACCTCTACT TAAATCCGTC CTGTTTAGCG ACTTCAGTCA ACTACAGCTC ACTCCATAGG 1132  
 CCAGAAATAC AATAAATCCT GTTTAGCGAC TTCAGTCAAC TACAGCTCAC TCCATAGGCC 1192  
 20 AGAAATACAA TAAA 1206

In addition, a complete gene map (Figure 5) and nucleotide sequences (SEQ. ID Nos. 3 through 29 and Figures 6A and 6B) of the chromosomal DNA of type 5 17 $\beta$ -HSD are provided. A more detailed description of the sequences will be provided *infra*.

25 The present invention includes methods for the synthetic production of type 5 17 $\beta$ -HSD, as well as peptides that are biologically functionally equivalent, and to methods of using these compounds to screen test compounds for their ability to inhibit or alter the enzymatic function. In addition, methods of producing antisense constructs to the type 5 17 $\beta$ -HSD gene's DNA or mRNA or portions thereof, and the  
 30 use of those antisense constructs to interfere with the transcription or translation of the enzyme are also provided.

35 The nucleotide sequence which encodes type 5 17 $\beta$ -HSD and recombinant expression vectors which include the sequence may be modified so long as they continue to encode a functionally equivalent enzyme. Moreover, it is contemplated, within the invention, that codons within the coding region may be altered, *inter alia*, in a manner which, given the degeneracy of the genetic code, continues to encode the same protein or one providing a functionally equivalent protein. It is believed that nucleotide sequences analogous to SEQ ID No. 1, or those that hybridize under stringent conditions to the coding region of SEQ ID No. 1, are likely to encode a type  
 40 5 17 $\beta$ -HSD functionally equivalent to that encoded by the coding region of SEQ ID No. 1, especially if such analogous nucleotide sequence is at least 700, preferably at

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least 850 and most preferably at least 969 nucleotides in length. As used herein, except where otherwise specified, "stringent conditions" means 0.1x SSC (0.3 M sodium chloride and 0.03M sodium citrate) and 0.1% sodium dodecyl sulphate (SDS) and 60° C.

5 It is also likely that tissues or cells from human or non-human sources and which tissues or cells have the enzymatic machinery to convert  $\Delta^4$ -dione to testosterone, or to convert progesterone to 20 $\alpha$ -hydroxyprogesterone, include a type 5 17 $\beta$ -HSD sufficiently analogous to human type 5 17 $\beta$ -HSD to be used in accordance with the present invention. In particular, cDNA libraries prepared from cells  
10 performing the foregoing conversions may be screening with probes in accordance with well known techniques prepared by reference to the nucleotides disclosed herein, and under varying degrees of stringency, in order to identify analogous cDNAs in other species. These analogous cDNAs are preferably at least 70% homologous to SEQ ID No. 1, more preferably at least 80% homologous, and most preferably at  
15 least 90% homologous. They preferably include stretches of perfect identity at least 10 nucleotides long, more preferably stretches of 15, 20 or even 30 nucleotides of perfect identity. Appropriate probes may be prepared from SEQ ID No. 1 or fragments thereof of suitable length, preferably at least 15 nucleotides in length. Confirmation with at least two distinct probes is preferred. Alternative isolation  
20 strategies, such as polymerase chain reaction (PCR) amplification, may also be used.

Homologous type 5 17 $\beta$ -HSDs so obtained, as well as the genes encoding them, are used in accordance with the invention in all of the ways for using SEQ ID No. 2 and SEQ ID No. 1, respectively.

Recombinant expression vectors can include the entire coding region for  
25 human type 5 17 $\beta$ -HSD as shown in SEQ ID No. 1, the coding region for human type 5 17 $\beta$ -HSD which has been modified, portions of the coding region for human type 5 17 $\beta$ -HSD, the chromosomal DNA of type 5 17 $\beta$ -HSD, an antisense construct to type 5 17 $\beta$ -HSD, or portions of antisense constructs to type 5 17 $\beta$ -HSD.

In the context of the invention, "isolated" means having a higher purity than  
30 exists in nature, but does not require purification from a natural source. Isolated nucleotides encoding type 5 17 $\beta$ -HSD may be produced synthetically, or by isolating cDNA thereof from a cDNA library or by any of numerous other methods well understood in the art.

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In one embodiment, the invention provides an isolated nucleotide sequence encoding type 5 17 $\beta$ -hydroxysteroid dehydrogenase, said sequence being sufficiently homologous to SEQ ID No. 1 or a complement thereof, to hybridize under stringent conditions to the coding region of SEQ ID No. 1 or a complement thereof and said  
5 sequence encoding an enzyme which catalyzes the conversion of progesterone to 20 $\alpha$ -hydroxyprogesterone and the conversion of 4-androstenedione to testosterone.

In a further embodiment, the invention provides an isolated nucleotide sequence comprising at least ten consecutive nucleotides identical to 10 consecutive nucleotides in the coding region of SEQ ID No. 1, or the complement thereof.

10 In an additional embodiment, the invention provides an oligonucleotide sequence selected from the group consisting of SEQ ID Nos. 30 through 59.

In another embodiment, the invention provides a recombinant expression vector comprising a promoter sequence and an oligonucleotide sequence selected from the group of SEQ ID Nos. 30 to 59.

15 In a further embodiment, the invention provides a method of blocking synthesis of type 5 17 $\beta$ -HSD, comprising the step of introducing an oligonucleotide selected from the group consisting of SEQ ID Nos. 30 to 59 into cells.

In an additional embodiment, the invention provides an isolated chromosomal DNA fragment which upon transcription and translation encodes type 5 17 $\beta$ -  
20 hydroxysteroid dehydrogenase and wherein said fragment contains nine exons and wherein said fragment includes introns which are 16 kilobase pairs in length.

In another embodiment, the invention provides an isolated DNA sequence encoding type 5 17 $\beta$ -hydroxysteroid dehydrogenase, said sequence being sufficiently homologous to SEQ ID No. 3 or a complement thereof, to hybridize under stringent  
25 conditions to SEQ ID No. 3, or its complement.

In a further embodiment, the invention provides a method for producing type 5 17 $\beta$ -hydroxysteroid dehydrogenase, comprising the steps of preparing a recombinant host transformed or transfected with the vector of claim 3 and culturing said host under conditions which are conducive to the production of type 5 17 $\beta$ -hydroxysteroid  
30 dehydrogenase by said host.

In an additional embodiment, the invention provides a method for determining the inhibitory effect of a test compound on the enzymatic activity of type 5 17 $\beta$ -hydroxysteroid dehydrogenase, comprising the steps of providing type 5 17 $\beta$ -

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hydroxysteroid dehydrogenase; contacting said type 5 17 $\beta$ -hydroxysteroid dehydrogenase with said test compound; and thereafter determining the enzymatic activity of said type 5 17 $\beta$ -hydroxysteroid dehydrogenase in the presence of said test compound.

5 In an additional embodiment, the invention provides a method of interfering with the expression of type 5 17 $\beta$ -hydroxysteroid dehydrogenase, comprising the step of administering nucleic acids substantially identical to at least 15 consecutive nucleotides of SEQ ID No. 1 or a complement thereof.

10 In a further embodiment, there is provided a method of interfering with the synthesis of type 5 17 $\beta$ -hydroxysteroid dehydrogenase, comprising the step of administering antisense RNA complementary to mRNA encoded by at least 15 consecutive nucleotides of SEQ ID No. 1 or a complement thereof.

15 In an additional embodiment, the invention provides a method of interfering with the expression of type 5 17 $\beta$ -hydroxysteroid dehydrogenase, comprising the step of administering nucleic acids substantially identical to at least 15 consecutive nucleotides of SEQ ID No. 3 or a complement thereof.

20 In another embodiment, the invention provides a method of interfering with the synthesis of type 5 17 $\beta$ -hydroxysteroid dehydrogenase, comprising the step of administering antisense RNA complementary to mRNA encoded by at least 15 consecutive nucleotides of SEQ ID No. 3 or a complement thereof.

25 In a further embodiment, there is provided a method for determining the inhibitory effect of antisense nucleic acids on the enzymatic activity of type 5 17 $\beta$ -hydroxysteroid dehydrogenase, comprising the steps of providing a host system capable of expressing type 5 17 $\beta$ -hydroxysteroid dehydrogenase; introducing said antisense nucleic acids into said host system; and thereafter determining the enzymatic activity of said type 5 17 $\beta$ -hydroxysteroid dehydrogenase.

Other features and advantages of the present invention will become apparent from the following description of the invention which refers to the accompanying drawings.

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#### BRIEF DESCRIPTION OF THE DRAWINGS

Figures 1A and 1B are graphs showing the enzymatic activities of Type 5 17 $\beta$ -

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HSD on various substrates. The enzyme was expressed in embryonal kidney (293) cells (ATCC CRL 1573) which were transfected with a vector, prepared in accordance with the invention, and containing the gene encoding human type 5 17 $\beta$ -HSD. Figure 1A shows the substrate specificity of type 5 17 $\beta$ -HSD. The concentration of each substrate was 0.1  $\mu$ M. Figure 1B shows the time course amount of 20 $\alpha$ -HSD and 17 $\beta$ -HSD activities of cells transfected with vectors containing human type 5 17 $\beta$ -HSD. The substrates, progesterone (P) and  $\Delta^4$ -dione, were added at a concentration of 0.1  $\mu$ M;

Figure 2 is a map of a pCMV vector which is exemplary of one that can be used to transfect host cells in accordance with the invention;

Figure 3 is the cDNA sequence (SEQ ID No. 1) and the deduced amino acid sequence (SEQ ID No. 2) of human type 5 17 $\beta$ -HSD. The nucleotide sequence is numbered in the 5' to 3' direction with the adenosine of the initiation codon (ATG) designated as +11. The translation stop codon is indicated by asterisks. The potential post modification sites are underlined, wherein TSK = tyrosine sulfokinase; CK2 = casein kinase II; PKC = protein kinase C; NG = N-glycosylation; and NM = N-myristoylation;

Figure 4 is a comparison of the deduced amino acid sequence of human type 5 17 $\beta$ -HSD to the amino acid sequences of rabbit (rb), rat (r), and bovine (b) 20 $\alpha$ -HSD as well as human (h) and rat (r) 3 $\alpha$ -HSD, bovine prostaglandin f synthase (b pgfs) and frog  $\rho$ -crystallin (f  $\rho$ -crys). The amino sequences are indicated using the conventional single letter code and are numbered on the right. The dashes (-) and dots (.) indicate identical and missing amino acid residues, respectively;

Figure 5 is a map of the chromosomal DNA of a gene which encodes type 5 17 $\beta$ -HSD; and

Figures 6A and 6B are the nucleotide sequence of the chromosomal DNA of a gene which encodes type 5 17 $\beta$ -HSD.

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### DETAILED DESCRIPTION OF THE INVENTION

5 A gene encoding the enzyme, type 5 17 $\beta$ -HSD, has been isolated and encodes a protein having 323 amino acids with a calculated molecular weight of 36,844 daltons. As shown in Figure 3, the coding portion of this gene includes nucleotides +11 through 982, including the stop codon (and encodes amino acids +1 through 323), numbered in the 5' to 3' direction.

10 The chromosomal DNA fragment of the gene for type 5 17 $\beta$ -HSD has also been characterized. A map of the gene is provided in Figure 5. In particular, it was found, using primer extension analysis, that the gene includes 16 kilobase pairs (kb) and contained nine short exons. A portion of the 5' flanking region, as set forth in SEQ ID No. 3, of the genomic DNA includes 730 base pairs (bp). Exon I (SEQ ID No. 4) contains 37 nucleotides in the 5'-noncoding region and the nucleotides for the  
15 first 28 amino acids. The second intron region includes the nucleotides set forth in SEQ ID Nos. 5 and 6, which are 252 and 410 bp, respectively. These are joined by a 1.2 kb region which is not important and therefore, its sequence has been omitted. Exon 2 (SEQ ID No. 7) contains nucleotides for the following 56 amino acids of human type 5 17 $\beta$ -HSD. The following intron region includes SEQ ID Nos. 8 and 9,  
20 700 and 73 bp, respectively, which are joined by a 0.1 kb region for which the sequence has not been provided. Exon 3 (SEQ ID No. 10) includes the next 117 nucleotides which specify the following 39 amino acids. The fourth intron region is represented by SEQ ID Nos. 11 and 12, 152 and 208 nucleotides in length, respectively, with a 0.9 kb region in between which has not been provided. Exon 4  
25 (SEQ ID No. 13) includes the next 78 bp which specify the following 26 amino acids of the enzyme. Intron region five contains SEQ ID Nos. 14 and 15, with 98 and 249 nucleotides, respectively, with a 0.1 kb region in the middle which has not been provided. The fifth exon (SEQ ID No. 16) contains nucleotides for the following 41 amino acids of human type 5 17 $\beta$ -HSD. The sixth intron region, set forth in SEQ ID  
30 Nos. 17 and 18 with 138 and 189 bp, respectively, also includes a 2.8 kb region which has not been provided. Exon 6 (SEQ ID No. 19) contains nucleotides for the following 36 amino acids of type 5 17 $\beta$ -HSD, as well as two nucleotides of the codon 227 (Trp). The next intron region includes a 136 bp portion (SEQ ID No. 20) and a

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66 bp portion (SEQ ID No. 21) which are joined by a 0.1 kb region which is not set forth. Exon 7 (SEQ ID No. 22) contains nucleotides for the third nucleotide of codon 227 (Trp) and nucleotides for the following 55 codons. The following intron region includes a 136 nucleotide region (SEQ ID No. 23), a 2.5 kb region which is not provided and a 286 bp region (SEQ ID No. 24). Exon 8 (SEQ ID No. 25) includes 83 nucleotides which code for the following 27 amino acids and 2 nucleotides of codon 310. The ninth intron region contains 713 nucleotides (SEQ ID No. 26) followed by a 1 kb region which has not been provided followed by a 415 nucleotide region (SEQ ID No. 27). Exon 9 (SEQ ID No. 28) contains the third nucleotide of codon 310, 42 nucleotides for the last 13 amino acids and a stop codon and approximately 200 nucleotides in the 3'-untranslated region. A polymorphic (GT)<sub>n</sub> repeat region that can be used to perform genetic linkage mapping of the type 5 17 $\beta$ -HSD can be found 255 nucleotides downstream from the TAA stop codon. SEQ ID No. 29 sets forth 109 bp of additional genomic sequence. The nucleotide sequence of the gene fragment, as described above, is provided in Figures 6A and 6B.

The type 5 17 $\beta$ -HSD enzyme can be produced by incorporating the nucleotide sequence for the coding portion of the gene into a vector which is then transformed or transfected into a host system which is capable of expressing the enzyme. The DNA can be maintained transiently in the host or can be stably integrated into the genome of the host cell. In addition, the chromosomal DNA can be incorporated into a vector and transfected into a host system for cloning.

In particular, for the cloning and expression of type 5 17 $\beta$ -HSD, any common expression vectors, such as plasmids, can be used. These vectors can be prokaryotic expression vectors including those derived from bacteriophage  $\lambda$  such as  $\lambda$ gt11 and  $\lambda$ EMBL3, *E. coli* strains such as pBR322 and Bluescript (Stratagene); or eukaryotic vectors, such as those in the pCMV family. Vectors incorporating an isolated human cDNA shown in Sequence ID No. 1 (ATCC Deposit No. ) and the chromosomal DNA as shown in Sequence ID Nos. 3 through 29 (ATCC Deposit No. ) for type 5 17 $\beta$ -HSD have been placed on deposit at the American Type Culture Collection (ATCC, Rockville, MD), in accordance with the terms of the Budapest Treaty, and will be made available to the public upon issuance of a patent based on the present patent application.

These vectors generally include appropriate replication and control sequences

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which are compatible with the host system into which the vectors are transfected. A promoter sequence is generally included. For prokaryotes, some representative promoters include  $\beta$ -lactamase, lactose, and tryptophan. In mammalian cells, commonly used promoters include, but are not limited to, adenovirus, cytomegalovirus (CMV) and simian virus 40 (SV40). The vector can also optionally include, as appropriate, an origin of replication, ribosome binding sites, RNA splice sites, polyadenylation sites, transcriptional termination sequences and/or a selectable marker. It is well understood that there are a variety of vector systems with various characteristics which can be used in the practice of the invention. A map of the pCMV vector, which is an example of a vector which can be used in the practice of the invention, is provided in Figure 2.

Commonly known host systems which are known for expressing an enzyme, and which may be transfected with an appropriate vector which includes a gene for Type 5  $17\beta$ -HSD can be used in the practice of the invention. These host systems include prokaryotic hosts, such as *E. coli*, bacilli, such as *Bacillus subtilis*, and other enterobacteria, such as *Salmonella*, *Serratia*, and *Pseudomonas* species. Eukaryotic microbes, including yeast cultures, can also be used. The most common of these is *Saccharomyces cerevisiae*, although other species are commercially available and can be used. Furthermore, cell cultures can be grown which are derived from mammalian cells. Some examples of suitable host cell lines include embryonal kidney (293), SW-13, chinese hamster ovary (CHO), HeLa, myeloma, Jurkat, COS-1, BHK, W138 and madin-darby canine kidney (MDCK). In the practice of the invention, the 293 cells are preferred.

Type 5  $17\beta$ -HSD, whether recombinantly produced as described herein, purified from nature, or otherwise produced, can be used in assays to identify compounds which inhibit or alter the activity of the enzyme. In particular, since type 5  $17\beta$ -HSD is shown to catalyze the conversion of progesterone to  $20\alpha$ -OH-P and the conversion of  $\Delta^4$ -dione to testosterone, this enzyme can be used to identify compounds which interfere with the production of these sex steroids. It is preferred that the enzyme be obtained directly from the recombinant host, wherein following expression, a crude homogenate is prepared which includes the enzyme. A substrate of the enzyme, such as progesterone or  $\Delta^4$ -dione and a compound to be tested are then mixed with the homogenate. The activity of the enzyme with and without the test compound

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is compared. Numerous methods are known which can be used to indicate the effects of the test compound on the activity of the substrate for easy detection of the relative amounts of substrate and product over time. For example, it is possible to label the substrate so that the label also stays on any product that is formed. Radioactive labels, such as  $C^{14}$  or  $H^3$ , which can be quantitatively analyzed are particularly useful.

It is preferred that the mixture of the enzyme, test compound and substrate be allowed to incubate for a predetermined amount of time. In addition, it is preferred that the product is separated from the substrate for easier analysis. A number of separation techniques are known, for example, thin layer chromatography (TLC), high pressure liquid chromatography (HPLC), spectrophotometry, gas chromatography, mass spectrophotometry and nuclear magnetic resonance (NMR). However, any known method which can differentiate between a substrate and a product can be used.

It is also contemplated that the gene for type 5  $17\beta$ -HSD or a portion thereof can be used to produce antisense nucleic acid sequences for inhibiting expression of Type 5  $17\beta$ -HSD *in vivo*. Thus activity of the enzyme and levels of its products (e.g. testosterone) may be reduced where desirable. In general, antisense nucleic acid sequences can interfere with transcription, splicing or translation processes. Antisense sequences can prevent transcription by forming a triple helix or hybridizing to an opened loop which is created by RNA polymerase or hybridizing to nascent RNA. On the other hand, splicing can advantageously be interfered with if the antisense sequences bind at the intersection of an exon and an intron. Finally, translation can be affected by blocking the binding of initiation factors or by preventing the assembly of ribosomal subunits at the start codon or by blocking the ribosome from the coding portion of the mRNA, preferably by using RNA that is antisense to the message. For further general information, see Hélène et al., *Biochimica et Biophysica Acta*, 1049:99-125 (1990), which is herein incorporated by reference in its entirety.

An antisense nucleic acid sequence is an RNA or single stranded DNA sequence which is complementary to the target portion of the target gene. These antisense sequences are introduced into cells where the complementary strand base pairs with the target portion of the target gene, thereby blocking the transcription, splicing or translation of the gene and eliminating or reducing the production of type 5  $17\beta$ -HSD. The length of the antisense nucleic acid sequence need be no more than is sufficient to interfere with the transcription, splicing or translation of functional type 5

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17 $\beta$ -HSD. Antisense strands can range in size from 10 nucleotides to the complete gene, however, about 10 to 50 nucleotides are preferred, and 15 to 25 nucleotides are most preferred.

Although it is contemplated that any portion of the gene could be used to produce antisense sequences, it is preferred that the antisense is directed to the coding portion of the gene or to the sequence around the translation initiation site of the mRNA or to a portion of the promoter. Some examples of specific antisense oligonucleotide sequences in the coding region which can be used to block type 5 17 $\beta$ -HSD synthesis include: TTTAGCTTTACACACTGCTGTT (SEQ ID No. 30);  
 5 TCCAAAGCTTTACTTCTCGG (SEQ ID No. 31); GATGAAAAGTGGACCA (SEQ ID No. 32); ATCTGTTGGTGAAAGTTC (SEQ ID No. 33);  
 10 TCCAGCTGCCTGCGGT (SEQ ID No. 34); CTTGTACTTGAGTCCTG (SEQ ID No. 35); CTCCGGTTGAAATACGGA (SEQ ID No. 36);  
 CATCGTTTGTCTCGTTGAGA (SEQ ID No. 37);  
 15 TCACTGTAAATAGTGGAGAT (SEQ ID No. 38); ATCTGAATATGGATAAT (SEQ ID No. 39). Examples of antisense oligonucleotide sequences which can block the splicing of the type 5 17 $\beta$ -HSD premessage are as follows:  
 TTCTCGGAACCTGGAGGAGC (SEQ ID No. 40);  
 GACACAGTACCTTTGAAGTG (SEQ ID No. 41);  
 20 TGGACCAAAGCTGCAGAGGT (SEQ ID No. 42);  
 CCTCACCTGGCTGAAATAGA (SEQ ID No. 43);  
 AAGCACTCACCTCCAGGTG (SEQ ID No. 44);  
 GACATTCTACCTGCAGTTGA (SEQ ID No. 45); CTCAAAAACCTATCAGAAA (SEQ ID No. 46);  
 GGAAACTTACCTATCACTGT (SEQ ID No. 47);  
 25 GCTAGCAAACTGAAAAGAG (SEQ ID No. 48). Examples of antisense oligonucleotide sequences which inhibit the promoter activity of type 5 17 $\beta$ -HSD include:  
 GAGAAATATTCATTCTG (SEQ ID No. 49);  
 CGAGTCCTGATAAAGCTG (SEQ ID No. 50); GATGAGGGTGCAAATAA (SEQ ID No. 51);  
 GGAGTGTTAATTAATAACAGTTT (SEQ ID No. 52);  
 30 CAGAGATTACAAAACAAT (SEQ ID No. 53);  
 TGCCTTTTTACATTTCAATCA (SEQ ID No. 54); ACACATAATTTAAAGGA (SEQ ID No. 55);  
 TTAAATTATTCAAAAGG (SEQ ID No. 56);  
 AAGAGAAATATTCATTTCTG (SEQ ID No. 57);

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CCCCTCCCCCACCCTGCA (SEQ ID No. 58); CTGCCGTGATAATGCCCC  
(SEQ ID No. 59).

As is well understood in the art, the oligonucleotide sequences can be modified in various manners in order to increase the effectiveness of the treatment with oligonucleotides. In particular, the sequences can be modified to include additional RNA to the 3' end of the RNA which can form a hairpin-loop structure and thereby prevent degradation by nucleases. In addition, the chemical linkages in the backbone of the oligonucleotides can be modified to also prevent cleavage by nucleases.

There are numerous methods which are known in the art for introducing the antisense strands into cells. One strategy is to incorporate the gene which encodes type 5 17 $\beta$ -HSD in the opposite orientation in a vector so that the RNA which is transcribed from the plasmid is complementary to the mRNA transcribed from the cellular gene. A strong promoter, such as pCMV, is generally included in the vector, upstream of the gene sequence, so that a large amount of the antisense RNA is produced and is available for binding sense mRNA. The vectors are then transfected into cells which are then administered. It is also possible to produce single stranded DNA oligonucleotides or antisense RNA and incorporate these into cells or liposomes which are then administered. The use of liposomes, such as those described in WO95/03788, which is herein incorporated by reference, is preferred. However, other methods which are well understood in the art can also be used to introduce the antisense strands into cells and to administer to these patients in need of such treatment.

The following is an example of the expression of human type 5 17 $\beta$ -HSD. This example is intended to be illustrative of the invention and it is well understood by those of skill in the art that modifications, alterations and different techniques can be used within the scope of the invention.

#### Expression of 20 $\alpha$ , 17 $\beta$ -HSD (Type 5 17 $\beta$ -HSD)

##### *Construction of the expression vector and nucleotide sequence determination*

The phage DNA were digested with EcoRI restriction enzyme and the resulting cDNA fragments were inserted in the EcoRI site downstream to the cytomegalovirus

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(CMV) promoter of the pCMV vector as shown in Figure 2. The recombinant pCMV plasmids were amplified in *Escherichia coli* DH5 $\alpha$  competent cells, and were isolated using the alkaline lysis procedure as described by Maniatis in *Molecular Cloning: A Laboratory Manual* (Cold Spring Harbor Press 1982). The sequencing of double-stranded plasmid DNA was performed according to the dideoxy chain termination method described by Sanger F. et al., *Proc. Natl. Acad. Sci.*, 74:5463-5467 (1977) using a T7 DNA polymerase sequencing kit (Pharmacia LKB Biotechnology). In order to avoid errors, all sequences were determined by sequencing both strands of the DNA. The oligonucleotide primers were synthesized using a 394 DNA/RNA synthesizer (Applied Biosystem).

As shown in Figure 2, the pCMV vector contains 582 nucleotides of the pCMV promoter, followed by 74 nucleotides of unknown origin which includes the EcoRI and HindIII sites, followed by 432 basepairs (bp) of a small t intron (fragment 4713 - 4570) and a polyadenylation signal (fragment 2825 - 2536) of SV40, followed by 156 nucleotides of unknown origin, followed by 1989 bp of the PvuII (628) to AatII (2617) fragment from the pUC 19 vector (New England Biolabs) which contains an *E. coli* origin of replication and an ampicillin resistance gene for propagation in *E. coli*.

#### 20 *Transient expression in transformed embryonal kidney (293) cells*

The vectors were transfected using the calcium phosphate procedure described by Kingston, R.E., In: *Current Protocols in Molecular Biology*, Ausubel et al. eds., pp. 9.1.1 - 9.1.9, John Wiley & Sons, N.Y. (1987) and used 1 to 10  $\mu$ g of recombinant plasmid DNA per  $10^6$  cells. The total amount of DNA is kept at 10 $\mu$ g of plasmid DNA per  $10^6$  cells by completing with pCMV plasmid without insert. The cells were initially plated at  $10^4$  cells/cm<sup>2</sup> in Falcon® culture flasks and grown in Dulbecco's modified Eagle's medium containing 10% (vol/vol) fetal bovine serum (hyclone, Logan, UT) under a humidified atmosphere of air/CO<sub>2</sub> (95%/5%) at 37°C and supplemented with 2 mM L-glutamine, 1 mM sodium pyruvate, 100 IU penicillin/ml, and 100  $\mu$ g streptomycin sulfate/ml.

#### *Assay of enzymatic activity*

The determination of enzymatic activity was performed as described by Luu-

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The et al., *Biochemistry*, 13:8861-8865 (1991) which is herein incorporated by reference. See also Lachance et al., *J. Biol. Chem.*, 265:20469 - 20475 (1990). Briefly, 0.1  $\mu$ M of the indicated  $^{14}$ C-labeled substrate (Dupont Inc. (Canada)), namely, dehydroepiandrosterone (DHEA), 4-androstene-3,17-dione ( $\Delta^4$ -dione), testosterone (T), estrone (E1), estradiol (E2), dihydrotestosterone (DHT), and progesterone (PROG), was added to freshly changed culture medium in a 6-well culture plate. After incubation for 1 hour, the steroids were extracted twice with 2 ml of ether. The organic phase was pooled and evaporated to dryness. The steroids were solubilized in 50  $\mu$ l of dichloromethane, applied to a Silica gel 60 thin layer chromatography (TLC) plate (Merck, Darmstad, Germany) and then separated by migration in the toluene-acetone (4:1) solvent system (Luu-The, V. et al., *J. Invest. Dermatol.*, 102:221-226 (1994) which is herein incorporated by reference). The substrates and metabolites were identified by comparison with reference steroids, revealed by autoradiography and quantitated using the Phosphoimager System (Molecular Dynamics, Sunnyvale, CA).

#### *Cloning of the type 5 17 $\beta$ -HSD genomic DNA clone*

The hybridization and sequencing methods were as described above and as previously described (Luu-The et al., *Mol. Endocrinol.*, 4:268-275 (1990); Luu-The et al., *DNA and Cell Biol.*, 14:511-518 (1995); Lachance et al., *J. Biol. Chem.*, 265:20469-20475 (1990); Lachance et al., *DNA and Cell Biol.* 10:701-711 (1991); Bernier et al., *J. Biol. Chem.*, 269, 28200-28205, (1994) which are herein incorporated by reference).

About 20 recombinant clones which gave the strongest hybridization signal were selected for second and third screening in order to isolate a single phage plaque. The two longest clones that hybridized with specific oligonucleotides probes located at the 5' and 3' regions of type 5 17 $\beta$ -HSD, respectively, were selected for mapping, subcloning and sequencing. As shown in Figures 5 and 6, the gene is included in approximately 16 kilobase pairs of introns and contains 9 short exons. A primer extension analysis using oligoprimer CAT-CAT-TTA-GCT-TTA-CAT-ACT-GCT-G located at positions 13 to 27, indicates that the start site is situated 37 nucleotides upstream from the ATG initiating codon.

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The sites and signatures in the primary protein sequence were detected using PC/Gene software (Intelli Genetics Inc., Mountain View, CA). This analysis revealed a potential N-glycosylation site at Asn-198; five protein kinase C sites at Ser-73, Thr-82, Ser-102, Ser-121, and Ser-221; five casein kinase II phosphorylation sites at Ser-129, Thr-146, Ser-221, Ser-271, and Thr-289; two N-myristoylation sites at Gly-158 and Gly-298; a tyrosine sulfatation site at Tyr-55; an aldo/keto reductase family signature 1 (25) at amino acids 158 to 168 and an aldo/keto reductase family putative active site signature at amino acids 262 to 280.

As described above, the enzymatic activity of the type 5 17 $\beta$ -HSD was evaluated by transfecting 293 cells with vectors which included the gene encoding human type 5 17 $\beta$ -HSD. The ability of the enzyme to catalyze the transformation of progesterone (P) to 20 $\alpha$ -hydroxyprogesterone (20 $\alpha$ -OH-P), 4-androstenedione ( $\Delta^4$ -dione) to testosterone (T), 5 $\alpha$ -androstane-3,17-dione (A-dione) to dihydrotestosterone (DHT), dehydroepiandrosterone (DHEA) to 5-androstene-3 $\beta$ ,17 $\beta$ -diol, and estrone (E1) to estradiol (E2) was analyzed. As shown in Figure 1A, the enzyme possesses high reductive 20 $\alpha$ -HSD activity, wherein progesterone (P) is transformed to the inactive 20 $\alpha$ -OH-P, and 17 $\beta$ -HSD activity, wherein  $\Delta^4$ -dione is converted to testosterone (T). However, 3 $\alpha$ -HSD activity which is responsible for the transformation of DHT to 5 $\alpha$ -androstane-3 $\alpha$ ,17 $\beta$ -diol is negligible. The ability of this enzyme to transform E1 and E2 was also negligible (Figure 1A). Figure 1B shows that the 20 $\alpha$ -HSD and 17 $\beta$ -HSD activities increased over time.

The isolated amino acid sequence of human type 5 17 $\beta$ -HSD was also compared with rabbit 20 $\alpha$ -HSD (rb), rat 20 $\alpha$ -HSD (r), human 3 $\alpha$ -HSD (h), rat 3 $\alpha$ -HSD (r), bovine prostaglandin f synthase (b pgfs), frog  $\rho$ -crystallin (f  $\rho$ -crys) and human type 1 and type 2 17 $\beta$ -HSDs (h) as shown in Figure 4. These sequences show 76.2%, 70.7%, 84.0%, 68.7%, 78.3%, 59.7%, 15.2% and 15.0% identity with type 5 17 $\beta$ -HSD, respectively.

Although the present invention has been described in relation to particular embodiments thereof, many other variations and modifications and other uses will be apparent to those skilled in the art.

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## SEQUENCE LISTING

- 5 (1) GENERAL INFORMATION:
- (i) APPLICANT: LUU-THE, Van  
LABRIE, Fernand
- 10 (ii) TITLE OF INVENTION: PRODUCTION AND USE OF ISOLATED TYPE 5  
17B-HYDROXYSTEROID DEHYDROGENASE
- (iii) NUMBER OF SEQUENCES: 59
- 15 (iv) CORRESPONDENCE ADDRESS:  
(A) ADDRESSEE: Ostrolenk, Faber, Gerb & Soffen  
(B) STREET: 1180 Avenue of the Americas  
(C) CITY: New York  
(D) STATE: NY  
(E) COUNTRY: US  
20 (F) ZIP: 10036-8403
- (v) COMPUTER READABLE FORM:  
(A) MEDIUM TYPE: Floppy disk  
(B) COMPUTER: IBM PC compatible  
25 (C) OPERATING SYSTEM: PC-DOS/MS-DOS  
(D) SOFTWARE: PatentIn Release #1.0, Version #1.30
- (vi) CURRENT APPLICATION DATA:  
(A) APPLICATION NUMBER:  
30 (B) FILING DATE:  
(C) CLASSIFICATION:
- (viii) ATTORNEY/AGENT INFORMATION:  
35 (A) NAME: Meilman, Edward  
(B) REGISTRATION NUMBER: 24,735  
(C) REFERENCE/DOCKET NUMBER: P/1259-313
- (ix) TELECOMMUNICATION INFORMATION:  
40 (A) TELEPHONE: (212) 382-0700  
(B) TELEFAX: (212) 382-0888  
(C) TELEX: 236925
- 45 (2) INFORMATION FOR SEQ ID NO:1:
- (i) SEQUENCE CHARACTERISTICS:  
(A) LENGTH: 1206 base pairs  
(B) TYPE: nucleic acid  
50 (C) STRANDEDNESS: single  
(D) TOPOLOGY: linear
- (ix) FEATURE:  
55 (A) NAME/KEY: CDS  
(B) LOCATION: 11..982

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## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:1:

5	GTGACAGGGA ATG GAT TCC AAA CAG CAG TGT GTA AAG CTA AAT GAT GGC Met Asp Ser Lys Gln Gln Cys Val Lys Leu Asn Asp Gly 1 5 10	49
10	CAC TTC ATG CCT GTA TTG GGA TTT GGC ACC.TAT GCA CCT CCA GAG GTT His Phe Met Pro Val Leu Gly Phe Gly Thr Tyr Ala Pro Pro Glu Val 15 20 25	97
15	CCG AGA AGT AAA GCT TTG GAG GTC ACC AAA TTA GCA ATA GAA GCT GGG Pro Arg Ser Lys Ala Leu Glu Val Thr Lys Leu Ala Ile Glu Ala Gly 30 35 40 45	145
20	TTC CGC CAT ATA GAT TCT GCT CAT TTA TAC AAT AAT GAG GAG CAG GTT Phe Arg His Ile Asp Ser Ala His Leu Tyr Asn Asn Glu Glu Gln Val 50 55 60	193
25	GGA CTG GCC ATC CGA AGC AAG ATT GCA GAT GGC AGT GTG AAG AGA GAA Gly Leu Ala Ile Arg Ser Lys Ile Ala Asp Gly Ser Val Lys Arg Glu 65 70 75	241
30	GAC ATA TTC TAC ACT TCA AAG CTT TGG TCC ACT TTT CAT CGA CCA GAG Asp Ile Phe Tyr Thr Ser Lys Leu Trp Ser Thr Phe His Arg Pro Glu 80 85 90	289
35	TTG GTC CGA CCA GCC TTG GAA AAC TCA CTG AAA AAA GCT CAA TTG GAC Leu Val Arg Pro Ala Leu Glu Asn Ser Leu Lys Lys Ala Gln Leu Asp 95 100 105	337
40	TAT GTT GAC CTC TAT CTT ATT CAT TCT CCA ATG TCT CTA AAG CCA GGT Tyr Val Asp Leu Tyr Ile Ile His Ser Pro Met Ser Leu Lys Pro Gly 110 115 120 125	385
45	GAG GAA CTT TCA CCA ACA GAT GAA AAT GGA AAA GTA ATA TTT GAC ATA Glu Glu Leu Ser Pro Thr Asp Glu Asn Gly Lys Val Ile Phe Asp Ile 130 135 140	433
50	GTG GAT CTC TGT ACC ACC TGG GAG GCC ATG GAG AAG TGT AAG GAT GCA Val Asp Leu Cys Thr Thr Trp Glu Ala Met Glu Lys Cys Lys Asp Ala 145 150 155	481
55	GGA TTG GCC AAG TCC ATT GGG GTG TCA AAC TTC AAC CGC AGG CAG CTG Gly Leu Ala Lys Ser Ile Gly Val Ser Asn Phe Asn Arg Arg Gln Leu 160 165 170	529
60	GAG ATG ATC CTC AAC AAG CCA GGA CTC AAG TAC AAG CCT GTC TGC AAC Glu Met Ile Leu Asn Lys Pro Gly Leu Lys Tyr Lys Pro Val Cys Asn 175 180 185	577
65	CAG GTA GAA TGT CAT CCG TAT TTC AAC CGG AGT AAA TTG CTA GAT TTC Gln Val Glu Cys His Pro Tyr Phe Asn Arg Ser Lys Leu Leu Asp Phe 190 195 200 205	625
70	TGC AAG TCG AAA GAT ATT GTT CTG GTT GCC TAT AGT GCT CTG GGA TCT Cys Lys Ser Lys Asp Ile Val Leu Val Ala Tyr Ser Ala Leu Gly Ser 210 215 220	673
75	CAA CGA GAC AAA CGA TGG GTG GAC CCG AAC TCC CCG GTG CTC TTG GAG Gln Arg Asp Lys Arg Trp Val Asp Pro Asn Ser Pro Val Leu Leu Glu 225 230 235	721
80	GAC CCA GTC CTT TGT GCC TTG GCA AAA AAG CAC AAG CGA ACC CCA GCC Asp Pro Val Leu Cys Ala Leu Ala Lys Lys His Lys Arg Thr Pro Ala 240 245 250	769

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	CTG ATT GCC CTG CGC TAC CAG CTG CAG CGT GGG GTT GTG GTC CTG GCC Leu Ile Ala Leu Arg Tyr Gln Leu Gln Arg Gly Val Val Val Leu Ala 255 260 265	817
5	AAG AGC TAC AAT GAG CAG CGC ATC AGA CAG AAC GTG CAG GTT TTT GAG Lys Ser Tyr Asn Glu Gln Arg Ile Arg Gln Asn Val Gln Val Phe Glu 270 275 280 285	865
10	TTC CAG TTG ACT GCA GAG GAC ATG AAA GCC ATA GAT GGC CTA GAC AGA Phe Gln Leu Thr Ala Glu Asp Met Lys Ala Ile Asp Gly Leu Asp Arg 290 295 300	913
15	AAT CTC CAC TAT TTT AAC AGT GAT AGT TTT GCT AGC CAC CCT AAT TAT Asn Leu His Tyr Phe Asn Ser Asp Ser Phe Ala Ser His Pro Asn Tyr 305 310 315	961
20	CCA TAT TCA GAT GAA TAT TAA CATGGAGACT TTGCCTGATG ATGTCTACCA Pro Tyr Ser Asp Glu Tyr * 320	1012
	GAAGGCCCTG TGTGTGGATG GTGACGCAGA GGACGTCTCT ATGCCGGTGA CTGGACATAT	1072
	CACCTCTACT TAAATCCGTC CTGTTTAGCG ACTTCAGTCA ACTACAGCTC ACTCCATAGG	1132
25	CCAGAAATAC AATAAATCCT GTTTAGCGAC TTCAGTCAAC TACAGCTCAC TCCATAGGCC AGAAATACAA TAAA	1192 1206
30	(2) INFORMATION FOR SEQ ID NO:2:	
	(i) SEQUENCE CHARACTERISTICS:	
	(A) LENGTH: 324 amino acids	
	(B) TYPE: amino acid	
35	(D) TOPOLOGY: linear	
	(ii) MOLECULE TYPE: protein	
40	(xi) SEQUENCE DESCRIPTION: SEQ ID NO:2:	
	Met Asp Ser Lys Gln Gln Cys Val Lys Leu Asn Asp Gly His Phe Met 1 5 10 15	
45	Pro Val Leu Gly Phe Gly Thr Tyr Ala Pro Pro Glu Val Pro Arg Ser 20 25 30	
	Lys Ala Leu Glu Val Thr Lys Leu Ala Ile Glu Ala Gly Phe Arg His 35 40 45	
50	Ile Asp Ser Ala His Leu Tyr Asn Asn Glu Glu Gln Val Gly Leu Ala 50 55 60	
	Ile Arg Ser Lys Ile Ala Asp Gly Ser Val Lys Arg Glu Asp Ile Phe 65 70 75 80	
55	Tyr Thr Ser Lys Leu Trp Ser Thr Phe His Arg Pro Glu Leu Val Arg 85 90 95	
60	Pro Ala Leu Glu Asn Ser Leu Lys Lys Ala Gln Leu Asp Tyr Val Asp 100 105 110	
	Leu Tyr Leu Ile His Ser Pro Met Ser Leu Lys Pro Gly Glu Glu Leu 115 120 125	
65	Ser Pro Thr Asp Glu Asn Gly Lys Val Ile Phe Asp Ile Val Asp Leu 130 135 140	

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Cys Thr Thr Trp Glu Ala Met Glu Lys Cys Lys Asp Ala Gly Leu Ala  
 145 150 155 160  
 5 Lys Ser Ile Gly Val Ser Asn Phe Asn Arg Arg Gln Leu Glu Met Ile  
 165 170 175  
 Leu Asn Lys Pro Gly Leu Lys Tyr Lys Pro Val Cys Asn Gln Val Glu  
 180 185 190  
 10 Cys His Pro Tyr Phe Asn Arg Ser Lys Leu Leu Asp Phe Cys Lys Ser  
 195 200 205  
 Lys Asp Ile Val Leu Val Ala Tyr Ser Ala Leu Gly Ser Gln Arg Asp  
 210 215 220  
 15 Lys Arg Trp Val Asp Pro Asn Ser Pro Val Leu Leu Glu Asp Pro Val  
 225 230 235 240  
 Leu Cys Ala Leu Ala Lys Lys His Lys Arg Thr Pro Ala Leu Ile Ala  
 245 250 255  
 20 Leu Arg Tyr Gln Leu Gln Arg Gly Val Val Val Leu Ala Lys Ser Tyr  
 260 265 270  
 25 Asn Glu Gln Arg Ile Arg Gln Asn Val Gln Val Phe Glu Phe Gln Leu  
 275 280 285  
 Thr Ala Glu Asp Met Lys Ala Ile Asp Gly Leu Asp Arg Asn Leu His  
 290 295 300  
 30 Tyr Phe Asn Ser Asp Ser Phe Ala Ser His Pro Asn Tyr Pro Tyr Ser  
 305 310 315 320  
 35 Asp Glu Tyr

## (2) INFORMATION FOR SEQ ID NO:3:

- 40 (i) SEQUENCE CHARACTERISTICS:  
 (A) LENGTH: 730 base pairs  
 (B) TYPE: nucleic acid  
 (C) STRANDEDNESS: single  
 (D) TOPOLOGY: linear  
 45 (ii) MOLECULE TYPE: DNA (genomic)  
 (iii) HYPOTHETICAL: NO  
 50 (iv) ANTI-SENSE: NO

55 (xi) SEQUENCE DESCRIPTION: SEQ ID NO:3:

AAGAACAAAT ACTATTAAGG CACTGCTTGC ATATATTAAA TGATGTCCAA ACTCCAAAAA 60  
 CTGTTAATAA TTAACACTCC AATAAAAACT ACACCAGAAT TTCTTTTAT TTGCACCCTC 120  
 60 ATCAGGATTA CAGCTTTATC AGGACTGCAT CTCTTCAGA AATGAATATT TCTCTTACAA 180  
 CGCAAAGAAA GAAAAATCAA AATAAATTTT CTGATTGAAA ATGTAAAAAG GCAAATATTT 240  
 TTACAGTTTT AACTTTAATT TTTTATTGAG GACCAACTGT TTGAAAAATT CTCATTAGTC 300  
 65 ATTCTTTTAA ATTATGTGTA TGTGAGAGAA AGACGTAAGA TGGTTAATTA TTTCAAATGA 360

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TGCAGTATAA AGAAGGGGCA TTATCACGGC AGAAACGAAA AAAGATATTT GTAGCTGGAG 420  
 GTTTTTATAG TCTAACATAT GGTGCTATT TGTCTACAA ATCCTTTTGA ATAATTTAAT 480  
 5 ATAGAGATTT CGAATAGAAA ATAATACTTT AGATAGAAAT TAATGAGTTT ATTATAACCA 540  
 TATATTATAA TAATTTACTT AGGAATTCTC TTTGATAAGA AACAAATGAA CTGAATGCAA 600  
 10 TTTTCTCCAC AGACCATATA AGACTGCCTA TGTACCTCCT CCTACATGCC ATTGGTTAAC 660  
 CATCAGTCAG TTTGCAGGGG TGGGGGGAGG GGTTTCCTGC CCATTGTTTT TGTAATCTCT 720  
 GAGGAGAAGC 730

15 (2) INFORMATION FOR SEQ ID NO:4:  
 (i) SEQUENCE CHARACTERISTICS:  
 (A) LENGTH: 121 base pairs  
 20 (B) TYPE: nucleic acid  
 (C) STRANDEDNESS: single  
 (D) TOPOLOGY: linear  
 (ii) MOLECULE TYPE: DNA (genomic)  
 25 (iii) HYPOTHETICAL: NO  
 (iv) ANTI-SENSE: NO  
 30 (ix) FEATURE:  
 (A) NAME/KEY: exon  
 (B) LOCATION: 38..121

35 (xi) SEQUENCE DESCRIPTION: SEQ ID NO:4:  
 AGCAGCAAAC ATTTGCTAGT CAGACAAGTG ACAGGGAATG GATTCCAAAC AGCAGTGTGT 60  
 40 AAAGCTAAAT GATGGCCACT TCATGCCTGT ATTGGGATTT GGCACCTATG CACCTCCAGA 120  
 G 121

(2) INFORMATION FOR SEQ ID NO:5:  
 45 (i) SEQUENCE CHARACTERISTICS:  
 (A) LENGTH: 252 base pairs  
 (B) TYPE: nucleic acid  
 (C) STRANDEDNESS: single  
 50 (D) TOPOLOGY: linear  
 (ii) MOLECULE TYPE: DNA (genomic)  
 (iii) HYPOTHETICAL: NO  
 55 (iv) ANTI-SENSE: NO

60 (xi) SEQUENCE DESCRIPTION: SEQ ID NO:5:  
 GTAAGAATAA TTCCTTTTAG TTTCGGATT TCAAAAGAAT AAACCTAGTA GAAGTGAAAC 60  
 65 CCGTATTGGG TTGTAAGGTT CGTGTTCCTA CCTTACTCTG GATGACTCAC TGGTCTAGGT 120  
 TTCCTAGGCT AGGAGAAAAA AGTAGGCAAT CCTTGTCTG CATTGAGGTC CATTCTATG 180

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GTCACGTACT GCTTATTTTT CGTTTGTGCA CTGTTTCTTT CTTCTGTTCA TGTCTAGTTC 240  
 CCAGCTTGGC AG 252

5 (2) INFORMATION FOR SEQ ID NO:6:

    (i) SEQUENCE CHARACTERISTICS:  
         (A) LENGTH: 410 base pairs  
         (B) TYPE: nucleic acid  
         (C) STRANDEDNESS: single  
         (D) TOPOLOGY: linear

10

    (ii) MOLECULE TYPE: DNA (genomic)

15

    (iii) HYPOTHETICAL: NO

    (iv) ANTI-SENSE: NO

20

    (xi) SEQUENCE DESCRIPTION: SEQ ID NO:6:

25 GGAAGTCTGA GTGAGCATTC TGTGTAATAT CACTGGGAGA GAACTCATAT GAGCTTGCAC 60  
 CGTTTCCCTT CTATACTCCA TGTGATTTTT ACCATGTATA ATATCACTAT ATTAAAAATA 120  
 ATTAGGACTA TTTCAGTCAT GTTAACTTTT CCAACAAATC ACTGAATCTG AGGGTGTTAT 180  
 30 GTGGTACCTC CATAACAGTG ATCAACCAGA GATTGCCTGA GACTGAAGGT GTTCTGCGGA 240  
 TGCTCAACCT TTATTACTAA CCAGGAAAGA CTCAGGCAAA CTGAGATGGA CTTTTCACCC 300  
 35 CACATACAGA CAGGAGGAAA AGCTGATTCT TGTATAAAG TCAATGCTTG TGCCTGAACT 360  
 ACCTCTCAGC CACAGTGATC ACCAGATACT ACCTTTGGTT GCTCCTCCAG 410

(2) INFORMATION FOR SEQ ID NO:7:

40

    (i) SEQUENCE CHARACTERISTICS:  
         (A) LENGTH: 168 base pairs  
         (B) TYPE: nucleic acid  
         (C) STRANDEDNESS: single  
         (D) TOPOLOGY: linear

45

    (ii) MOLECULE TYPE: DNA (genomic)

    (iii) HYPOTHETICAL: NO

50

    (iv) ANTI-SENSE: NO

    (ix) FEATURE:  
         (A) NAME/KEY: exon  
         (B) LOCATION: 1..168

55

    (xi) SEQUENCE DESCRIPTION: SEQ ID NO:7:

60 GTTCCGAGAA GTAAAGCTTT GGAGGTCACA AAATTAGCAA TAGAAGCTGG GTTCCGCCAT 60  
 ATAGATTCTG CTCATTTATA CAATAATGAG GAGCAGGTTG GACTGGCCAT CCGAAGCAAG 120  
 65 ATTGCAGATG GCAGTGTGAA GAGAGAAGAC ATATTCTACA CTTCAAAG 168

(2) INFORMATION FOR SEQ ID NO:8:

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- (i) SEQUENCE CHARACTERISTICS:  
 (A) LENGTH: 700 base pairs  
 (B) TYPE: nucleic acid  
 (C) STRANDEDNESS: single  
 (D) TOPOLOGY: linear
- (ii) MOLECULE TYPE: DNA (genomic)
- (iii) HYPOTHETICAL: NO
- (iv) ANTI-SENSE: NO
- (xi) SEQUENCE DESCRIPTION: SEQ ID NO:8:
- |   |     |
|---|-----|
| GTACTGTGTC TATGATGAGC TTGTGTGCAC ATGTATTTAT TGTGATTGTG TGGAGATGAC | 60  |
| AATTCTATGA CTGGATGAGT AGTTGTGGGT GAATTTTGCT TCTGGGTTCA AATTTATTCA | 120 |
| CACATACTCA CATACTAAAA CTGAAATCAA AATCAAGGAA TGATGATCAC TTTTCATTTT | 180 |
| GGCTGTGTTT CAATTATGA CCTGAAAGTC CCTTACTTT TTTGAGCTTC AGCCGAGATC   | 240 |
| AGTGTGATTT GACATGTGCT ATAGAATCAC AGAGAACAAT AATCATGTTA TGGTTTTTCT | 300 |
| TATCGCCTGG GTGATTTTCT AAGATTTCTT ATTATTCTCT CAATTGCTAT CTTTATCAGT | 360 |
| GAGATAGAAA GCAATATAAG AAAGCTCTGG GAGTATTAAT TAATAGACAC TTAAATTGTC | 420 |
| CTAAATTGTG TCCAGCATAG TGAGCATGTT CAAACTTGT TTTACCCCCC TTTTATGTTG  | 480 |
| CTTTAGTTTC TAAGCAACAT AAATAGCTAT TCTTAAGCAT TGGGTTGAAT GGATAGAAGA | 540 |
| ATTAGACTGT TAAATGAGT TGTAAGTCT ACTGAAGATA ATTCAGGTAA CATCATAGTT   | 600 |
| ATTACTTAAT ACTAATCTTT ACATTTTAAG AATTTACTCC TATCATTAG TAGATGTACA  | 660 |
| AACTATACAT CCAACGTATA ATAAAGTTTA TAAGGATAGG                       | 700 |
- (2) INFORMATION FOR SEQ ID NO:9:
- (i) SEQUENCE CHARACTERISTICS:  
 (A) LENGTH: 73 base pairs  
 (B) TYPE: nucleic acid  
 (C) STRANDEDNESS: single  
 (D) TOPOLOGY: linear
- (ii) MOLECULE TYPE: DNA (genomic)
- (iii) HYPOTHETICAL: NO
- (iv) ANTI-SENSE: NO
- (xi) SEQUENCE DESCRIPTION: SEQ ID NO:9:
- |   |    |
|---|----|
| ACTAGATGGC ACAAAGTAAT AAGATTTGCT CAAGCATTCA TTCAAATCA CTCCATTCT | 60 |
| TTAACCTCTG CAG  | 73 |
- (2) INFORMATION FOR SEQ ID NO:10:
- (i) SEQUENCE CHARACTERISTICS:

- 25 -

(A) LENGTH: 117 base pairs  
 (B) TYPE: nucleic acid  
 (C) STRANDEDNESS: single  
 (D) TOPOLOGY: linear

5 (ii) MOLECULE TYPE: DNA (genomic)

(iii) HYPOTHETICAL: NO

10 (iv) ANTI-SENSE: NO

(ix) FEATURE:  
 (A) NAME/KEY: exon  
 (B) LOCATION: 1..117

15 (xi) SEQUENCE DESCRIPTION: SEQ ID NO:10:

20 CTTTGGTCCA CTTTTCATCG ACCAGAGTTG GTCCGACCAG CCTTGAAAA CTCACTGAAA 60  
 AAAGCTCAAT TGGACTATGT TGACCTCTAT CTTATTCATT CTCCAATGTC TCTAAAG 117

25 (2) INFORMATION FOR SEQ ID NO:11:

(i) SEQUENCE CHARACTERISTICS:  
 (A) LENGTH: 152 base pairs  
 (B) TYPE: nucleic acid  
 (C) STRANDEDNESS: single  
 (D) TOPOLOGY: linear

30 (ii) MOLECULE TYPE: DNA (genomic)

(iii) HYPOTHETICAL: NO

35 (iv) ANTI-SENSE: NO

40 (xi) SEQUENCE DESCRIPTION: SEQ ID NO:11:

GTATGCAGTT TGTATGAGCA TAAAATTGCG CTCTGCTGT CATTATAAAC ATTGTTTATC 60  
 45 TGGATAGTTG AACAGAGCTT TTTATTAGGA GGATGTAGGG ATTATCACAC AGAAGAAGAA 120  
 CCGTAAGTGG AACACCTAAT TTCCTTTCTT TC 152

50 (2) INFORMATION FOR SEQ ID NO:12:

(i) SEQUENCE CHARACTERISTICS:  
 (A) LENGTH: 208 base pairs  
 (B) TYPE: nucleic acid  
 (C) STRANDEDNESS: single  
 (D) TOPOLOGY: linear

55 (ii) MOLECULE TYPE: DNA (genomic)

(iii) HYPOTHETICAL: NO

60 (iv) ANTI-SENSE: NO

65 (xi) SEQUENCE DESCRIPTION: SEQ ID NO:12:

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ATATAATATT TGTAAGAGAT TAGAGGAAGC CTGTCTCCTG AATACATTCC TTATACCTTC 60  
 ATATGTAAAA CACTTAGCAC ATATCACTTT CTGGAGCATT GTACCACCTG TCTCATGGAG 120  
 5 GATTAGTGTC CTAAAGGTA CCTGGGGTTA CAGCTATGAG TGGAGAAATT AATTTGTGAC 180  
 ATCATTAAAA TGA CTGCTTC TATTTT CAG 208

(2) INFORMATION FOR SEQ ID NO:13:

10 (i) SEQUENCE CHARACTERISTICS:  
 (A) LENGTH: 78 base pairs  
 (B) TYPE: nucleic acid  
 15 (C) STRANDEDNESS: single  
 (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA (genomic)

20 (iii) HYPOTHETICAL: NO  
 (iv) ANTI-SENSE: NO

25 (ix) FEATURE:  
 (A) NAME/KEY: exon  
 (B) LOCATION: 1..78

30 (xi) SEQUENCE DESCRIPTION: SEQ ID NO:13:  
 CCAGGTGAGG AACTTTCACC AACAGATGAA AATGGAAAAG TAATATTTGA CATAGTGGAT 60  
 CTCTGTACCA CCTGGGAG 78

35 (2) INFORMATION FOR SEQ ID NO:14:

40 (i) SEQUENCE CHARACTERISTICS:  
 (A) LENGTH: 98 base pairs  
 (B) TYPE: nucleic acid  
 (C) STRANDEDNESS: single  
 (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA (genomic)

45 (iii) HYPOTHETICAL: NO  
 (iv) ANTI-SENSE: NO

50 (xi) SEQUENCE DESCRIPTION: SEQ ID NO:14:

55 GTGAGTGCTT GGCGGAGAGG ACACAGAGAA GGATGACAAA AAGAGAAAAT CTGTTTCCCA 60  
 GGTTCGATAG GAAAGAATGG AATATGCACC ATTAGATC 98

(2) INFORMATION FOR SEQ ID NO:15:

60 (i) SEQUENCE CHARACTERISTICS:  
 (A) LENGTH: 249 base pairs  
 (B) TYPE: nucleic acid  
 (C) STRANDEDNESS: single  
 65 (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA (genomic)

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(iii) HYPOTHETICAL: NO

(iv) ANTI-SENSE: NO

5

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:15:

10 GACAGGAATC TCTTCCTTG CTTGTGCATT AATCTATGCA GTTCCTAAG GAAGAGATAG 60  
 AAATTCTTAC TCTTGCTGCC TCTATCTTCT TCCCTATTT GCTGTTTGAA TTTTCTTTT 120  
 15 TTTGACAATC ACTGCTAGCT ATTTTCATTG TCATACTTG AAAGTTGTG CTCTCACAGT 180  
 TCTGTCTTGC ATTTACCGTG ATTTGCAGCC AACTGCACAA ATAATTCCTC ACAACCCCTT 240  
 TCTCCACAG 249

20 (2) INFORMATION FOR SEQ ID NO:16:

(i) SEQUENCE CHARACTERISTICS:  
 (A) LENGTH: 123 base pairs  
 25 (B) TYPE: nucleic acid  
 (C) STRANDEDNESS: single  
 (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA (genomic)

30 (iii) HYPOTHETICAL: NO

(iv) ANTI-SENSE: NO

35 (ix) FEATURE:

(A) NAME/KEY: exon  
 (B) LOCATION: 1..123

40 (xi) SEQUENCE DESCRIPTION: SEQ ID NO:16:

GCCATGGAGA AGTGTAAGGA TGCAGGATTG GCCAAGTCCA TTGGGGTGTC AAAC TTCAAC 60  
 45 CGCAGGCAGC TGGAGATGAT CCTCAACAAG CCAGGACTCA AGTACAAGCC TGTCTGCAAC 120  
 CAG 123

(2) INFORMATION FOR SEQ ID NO:17:

50 (i) SEQUENCE CHARACTERISTICS:  
 (A) LENGTH: 138 base pairs  
 (B) TYPE: nucleic acid  
 (C) STRANDEDNESS: single  
 55 (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA (genomic)

(iii) HYPOTHETICAL: NO

60 (iv) ANTI-SENSE: NO

65 (xi) SEQUENCE DESCRIPTION: SEQ ID NO:17:

GTGAGCTCCC TTGGCCTTCT CTCCTTTCGG TTCTTCATGC CCCCTCTTCC TGTCTATTG 60

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CCAAATATCT GTTTGTTTTG TCCCAGTTAT CTTTGTGAAG TAGAAGATTA TCTAGAGAGC 120  
 5 AAAGCTTCTG TCAAGAAA 138

(2) INFORMATION FOR SEQ ID NO:18:

(i) SEQUENCE CHARACTERISTICS:  
 10 (A) LENGTH: 189 base pairs  
 (B) TYPE: nucleic acid  
 (C) STRANDEDNESS: single  
 (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA (genomic) 15  
 (iii) HYPOTHETICAL: NO  
 (iv) ANTI-SENSE: NO 20

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:18:

25 ATTTCATTT ATACTTTTAG AAGATATATA AAATTTATTT CTATGAAAAA GGTTATTACT 60  
 TGACAATAAT ATCCTCAGCT CAAATATAAT GCTATACTGA TTATTATTCA GCTTCCTTAC 120  
 30 TTTCATCTTT TCAATATTAA CATAACTATT TCATATAAAT TGATGCTTCT CTCTTTTGGT 180  
 CAACTGCAG 189

(2) INFORMATION FOR SEQ ID NO:19:

35 (i) SEQUENCE CHARACTERISTICS:  
 (A) LENGTH: 110 base pairs  
 (B) TYPE: nucleic acid  
 (C) STRANDEDNESS: single  
 40 (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA (genomic)  
 (iii) HYPOTHETICAL: NO  
 45 (iv) ANTI-SENSE: NO

(ix) FEATURE:  
 50 (A) NAME/KEY: exon  
 (B) LOCATION: 1..110

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:19:

55 GTAGAATGTC ATCCGTATTT CAACCGGAGT AAATTGCTAG ATTTCTGCAA GTCGAAAGAT 60  
 ATTGTTCTGG TTGCCTATAG TGCTCTGGGA TCTCAACGAG ACAAACGATG 110

(2) INFORMATION FOR SEQ ID NO:20:

60 (i) SEQUENCE CHARACTERISTICS:  
 (A) LENGTH: 136 base pairs  
 (B) TYPE: nucleic acid  
 (C) STRANDEDNESS: single  
 65 (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA (genomic)

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(iii) HYPOTHETICAL: NO

5 (iv) ANTI-SENSE: NO

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:20:

10 GTAATAAAAA CAATGGGACC TTTACATAAA CCTTCATTTT GCAGAAAATT TTTTAGTCAG 60

AGCATCCTCA GTTTCCTGTA GTTAAGTTTC AAGTGGCTCA TGGAGAGGAA AGAGAATTGC 120

15 GTTTCTGACG AGATCT 136

(2) INFORMATION FOR SEQ ID NO:21:

20 (i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 66 base pairs

(B) TYPE: nucleic acid

(C) STRANDEDNESS: single

(D) TOPOLOGY: linear

25 (ii) MOLECULE TYPE: DNA (genomic)

(iii) HYPOTHETICAL: NO

30 (iv) ANTI-SENSE: NO

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:21:

35 TTTAGGGAGC TGCCTAACAA ACTATCGGCA GCCTCAGGGC CTCAGCCTTT CTGCCTTTCC 60

TTCCAG 66

40 (2) INFORMATION FOR SEQ ID NO:22:

(i) SEQUENCE CHARACTERISTICS:

45 (A) LENGTH: 166 base pairs

(B) TYPE: nucleic acid

(C) STRANDEDNESS: single

(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA (genomic)

50 (iii) HYPOTHETICAL: NO

(iv) ANTI-SENSE: NO

55 (ix) FEATURE:

(A) NAME/KEY: exon

(B) LOCATION: 1..166

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:22:

60 GGTTGGACCCG AACTCCCCGG TGCTCTTGGA GGACCCAGTC CTTTGTGCCT TGGCAAAAAA 60

65 GCACAAGCGA ACCCCAGCCC TGATTGCCCT GCGTACCAG CTGCAGCGTG GGGTTGTGGT 120

CCTGGCCAAG AGCTACAATG AGCAGCGCAT CAGACAGAAC GTGCAG 166

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## (2) INFORMATION FOR SEQ ID NO:23:

## (i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 136 base pairs  
 (B) TYPE: nucleic acid  
 (C) STRANDEDNESS: single  
 (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA (genomic)

(iii) HYPOTHETICAL: NO

(iv) ANTI-SENSE: NO

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:23:

1TGAGGAGCG GGGCTGTGGG CCTCAGGTCT CCTGCACAGT GTCCTTCACA CGTGTGCTTC 60  
 2TGTAAGGCT CTCAGGACAG CCTTGGGCCA GCTCCATTTC CCTGTATTTC CCATATGAAT 120  
 3GCTTTGCGTG CATCCT 136

## (2) INFORMATION FOR SEQ ID NO:24:

## (i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 286 base pairs  
 (B) TYPE: nucleic acid  
 (C) STRANDEDNESS: single  
 (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA (genomic)

(iii) HYPOTHETICAL: NO

(iv) ANTI-SENSE: NO

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:24:

1CCCTATCATG TGGGCACAAT GTCAGCGCTG TTTCTTCTCC ATTTTCTGTT GAAATTTTCT 60  
 2TTTGTCTGC AGAGTTGCAC AGTTTCAATA CATAATATCT AGGAATGGAT TTCTGCTTAT 120  
 3TTTCGTGAG CTATTCATTG ACCCACCTGA GTGTTTAGAG CTGACTTCTA TAACTGTTTA 180  
 4AACTTACCA ATATTTTAAG TATTGTCTCT GCACCCTACT GTCTAATATA CTTGGGGATT 240  
 5CACAACGGC AATCTAAAAA TAATAAAAGT TTTTATTTC TGATAG 286

## (2) INFORMATION FOR SEQ ID NO:25:

## (i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 83 base pairs  
 (B) TYPE: nucleic acid  
 (C) STRANDEDNESS: single  
 (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA (genomic)

(iii) HYPOTHETICAL: NO

(iv) ANTI-SENSE: NO

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(ix) FEATURE:  
 (A) NAME/KEY: exon  
 (B) LOCATION: 1..83

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:25:

GTTTTTGAGT TCCAGTTGAC TGCAGAGGAC ATGAAAGCCA TAGATGGCCT AGACAGAAAT 60  
 CTCCACTATT TTAACAGTGA TAG 83

(2) INFORMATION FOR SEQ ID NO:26:

(i) SEQUENCE CHARACTERISTICS:  
 (A) LENGTH: 713 base pairs  
 (B) TYPE: nucleic acid  
 (C) STRANDEDNESS: single  
 (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA (genomic)

(iii) HYPOTHETICAL: NO

(iv) ANTI-SENSE: NO

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:26:

GTAAGTTTCC TTTGTAAATG GGTGATCTAA TTTATTTCTG GAGAAGGAAT GTAGGATGGG 60  
 TGTTGAGAGT GACCTCCATA CCAGAGGGAC AGAGGCCAAT GTGAGTCAGA GGTGAGACTG 120  
 GAACTCTCCT GCTGGATTCA CTCCAGAGCT CTGTTCTCTG GCAGGGTGAG TGGGCAGGGA 180  
 TCAGCATGGG TCAACCTGTG CCTCTGCTCT CTTGACTCCA TGGAACCTTC CAGAGCAGCC 240  
 AACATCATTG CCAAGTCTGC ACGTTCATA TAGGCCTGGT GTTCTACCA CTGGACATGC 300  
 TGTGGATACT GCCCATGTGA CTTCATTAGA TGTTTCCAAA TCTGTGCTTA TATCACATTG 360  
 TCCCAAACCT GTCAGCTCC TTATCAAATC AAAAACATTT CCATCAACTT TGTGGTCCAG 420  
 GTGCCAATTC CCACCTCCTT CATATGGAAT TGCTTGCTAG ATCCTGTCAA TTCAGCATCT 480  
 TTTATTATTT CAAATGTTTT TCCTCCTTCT CTTGACAGT TTGTTTCATGC CCCAACTCT 540  
 GCTTTTGCCT CCAGAAAGCC TTCCTTAGTG GAGTGAATAG GAGTGCTTGT CTTGATTTC 600  
 CTGCAATATG GAGCTCTCAA GGCAGAGAAT TAAAAAAAT TAAAAATCAA GGAGTGTGAG 660  
 TGTGGAGGCA GAAGCTCCAT TGTGTATAT AATTGTAGC TGATAAAGA TCT 713

(2) INFORMATION FOR SEQ ID NO:27:

(i) SEQUENCE CHARACTERISTICS:  
 (A) LENGTH: 415 base pairs  
 (B) TYPE: nucleic acid  
 (C) STRANDEDNESS: single  
 (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA (genomic)

(iii) HYPOTHETICAL: NO

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(iv) ANTI-SENSE: NO

5

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:27:

10 TTTAATGCAC TGTAGCTCCT TGGATATTAG ACCCTATATC ATATATAACA ATTTACATT 60  
 CTGAATCTTA CAAAATATAT TGCATACAGT AGGCAGTAGC AGGTAATAAG TAAAGTAACA 120  
 AAAGAAAGTA TAATCAGAGT ATCTCTGCTC TGCTGACAGA TGTACAGGAA TATACTTGAA 180  
 15 TATTTGACTT TGTGTGTTTT ACGTGTTAAC TTCCAGATAA GGGAAATATGA TTGAATAATT 240  
 TATTATTTTG AAAATACTGT ATTATGAAGC CATGTTTATA AAGGTAAGAA AGGCAGATTC 300  
 20 TACAACTAGT CAGACAACCT AACATTCATA CTAATGACAG CTTCAATTGAA ATCACTTTAC 360  
 TACTCCCTTA GTAATGGAGT CATTGCATTT ATATTATACA TTATTCTCTT TTCAG 415

(2) INFORMATION FOR SEQ ID NO:28:

25

(i) SEQUENCE CHARACTERISTICS:  
 (A) LENGTH: 230 base pairs  
 (B) TYPE: nucleic acid  
 (C) STRANDEDNESS: single  
 (D) TOPOLOGY: linear

30

(ii) MOLECULE TYPE: DNA (genomic)

(iii) HYPOTHETICAL: NO

35

(iv) ANTI-SENSE: NO

(ix) FEATURE:

40

(A) NAME/KEY: exon  
 (B) LOCATION: 1..230

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:28:

45 TTTTGCTAGC CACCCTAATT ATCCATATTC AGATGAATAT TAACATGGAG GGCTTTGCCT 60  
 GATGATGTCT ACCAGAAGGC CCTGTGTGTG GATGGTGACG CAGAGGACGT CTCTATGCCG 120  
 50 GTGACTGGAC ATATCACCTC TACTTAAATC CGTCCTGTTT AGCGACTTCA GTCAACTACA 180  
 GCTGAGTCCA TAGGCCAGAA AGACAATAAA TTTTATCAT TTTGAAATAA 230

(2) INFORMATION FOR SEQ ID NO:29:

55

(i) SEQUENCE CHARACTERISTICS:  
 (A) LENGTH: 109 base pairs  
 (B) TYPE: nucleic acid  
 (C) STRANDEDNESS: single  
 (D) TOPOLOGY: linear

60

(ii) MOLECULE TYPE: DNA (genomic)

(iii) HYPOTHETICAL: NO

65

(iv) ANTI-SENSE: NO

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(xi) SEQUENCE DESCRIPTION: SEQ ID NO:29:

5 TTGAATGTTT TCTCAAAGAT TCTTTACCTA CTCTGTTCTG TAGTGTGTGT TTTCTTCTGG 60  
CTCAGAAGTG TGTGTGTGTG TGTGTGTGCT TTCTTCTGGC TCAACAGGG 109

(2) INFORMATION FOR SEQ ID NO:30:

10 (i) SEQUENCE CHARACTERISTICS:  
(A) LENGTH: 22 base pairs  
(B) TYPE: nucleic acid  
15 (C) STRANDEDNESS: single  
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA (genomic)

20 (iii) HYPOTHETICAL: NO  
(iv) ANTI-SENSE: YES

25 (xi) SEQUENCE DESCRIPTION: SEQ ID NO:30:

TTTAGCTTTA CACACTGCTG TT 22

(2) INFORMATION FOR SEQ ID NO:31:

30 (i) SEQUENCE CHARACTERISTICS:  
(A) LENGTH: 20 base pairs  
35 (B) TYPE: nucleic acid  
(C) STRANDEDNESS: single  
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA (genomic)

40 (iii) HYPOTHETICAL: NO  
(iv) ANTI-SENSE: YES

45 (xi) SEQUENCE DESCRIPTION: SEQ ID NO:31:

50 TCCAAAGCTT TACTTCTCGG 20

(2) INFORMATION FOR SEQ ID NO:32:

55 (i) SEQUENCE CHARACTERISTICS:  
(A) LENGTH: 16 base pairs  
(B) TYPE: nucleic acid  
(C) STRANDEDNESS: single  
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA (genomic)

60 (iii) HYPOTHETICAL: NO  
(iv) ANTI-SENSE: YES

65

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(xi) SEQUENCE DESCRIPTION: SEQ ID NO:32:

GATGAAAAGT GGACCA

16

5 2) INFORMATION FOR SEQ ID NO:33:

(i) SEQUENCE CHARACTERISTICS:

10 (A) LENGTH: 18 base pairs  
(B) TYPE: nucleic acid  
(C) STRANDEDNESS: single  
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA (genomic)

15 (iii) HYPOTHETICAL: NO

(iv) ANTI-SENSE: YES

20

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:33:

25 ATCTGTTGGT GAAAGTTC

18

2) INFORMATION FOR SEQ ID NO:34:

(i) SEQUENCE CHARACTERISTICS:

30 (A) LENGTH: 16 base pairs  
(B) TYPE: nucleic acid  
(C) STRANDEDNESS: single  
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA (genomic)

35 (iii) HYPOTHETICAL: NO

(iv) ANTI-SENSE: YES

40

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:34:

45 TCCAGCTGCC TCGCGT

16

2) INFORMATION FOR SEQ ID NO:35:

(i) SEQUENCE CHARACTERISTICS:

50 (A) LENGTH: 17 base pairs  
(B) TYPE: nucleic acid  
(C) STRANDEDNESS: single  
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA (genomic)

55 (iii) HYPOTHETICAL: NO

(iv) ANTI-SENSE: YES

60

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:35:

65 CTGTACTTG AGTCCTG

17

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(2) INFORMATION FOR SEQ ID NO:36:

5 (i) SEQUENCE CHARACTERISTICS:  
(A) LENGTH: 18 base pairs  
(B) TYPE: nucleic acid  
(C) STRANDEDNESS: single  
(D) TOPOLOGY: linear

10 (ii) MOLECULE TYPE: DNA (genomic)  
(iii) HYPOTHETICAL: NO  
(iv) ANTI-SENSE: YES

15 (xi) SEQUENCE DESCRIPTION: SEQ ID NO:36:  
20 CTCGCGTTGA AATACGGA 18

(2) INFORMATION FOR SEQ ID NO:37:

25 (i) SEQUENCE CHARACTERISTICS:  
(A) LENGTH: 20 base pairs  
(B) TYPE: nucleic acid  
(C) STRANDEDNESS: single  
(D) TOPOLOGY: linear

30 (ii) MOLECULE TYPE: DNA (genomic)  
(iii) HYPOTHETICAL: NO  
(iv) ANTI-SENSE: YES

35 (xi) SEQUENCE DESCRIPTION: SEQ ID NO:37:  
40 CATCGTTTGT CTCGTTGAGA 20

(2) INFORMATION FOR SEQ ID NO:38:

45 (i) SEQUENCE CHARACTERISTICS:  
(A) LENGTH: 22 base pairs  
(B) TYPE: nucleic acid  
(C) STRANDEDNESS: single  
(D) TOPOLOGY: linear

50 (ii) MOLECULE TYPE: DNA (genomic)  
(iii) HYPOTHETICAL: NO  
(iv) ANTI-SENSE: YES

55 (xi) SEQUENCE DESCRIPTION: SEQ ID NO:38:  
60 TCACTGTAA AATAGTGGAG AT 22

(2) INFORMATION FOR SEQ ID NO:39:

65 (i) SEQUENCE CHARACTERISTICS:  
(A) LENGTH: 17 base pairs

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(B) TYPE: nucleic acid  
(C) STRANDEDNESS: single  
(D) TOPOLOGY: linear

5 (ii) MOLECULE TYPE: DNA (genomic)  
(iii) HYPOTHETICAL: NO  
10 (iv) ANTI-SENSE: YES

15 (xi) SEQUENCE DESCRIPTION: SEQ ID NO:39:  
ATCTGAATAT GGATAAT 17  
(2) INFORMATION FOR SEQ ID NO:40:

20 (i) SEQUENCE CHARACTERISTICS:  
(A) LENGTH: 20 base pairs  
(B) TYPE: nucleic acid  
(C) STRANDEDNESS: single  
25 (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA (genomic)  
(iii) HYPOTHETICAL: NO  
30 (iv) ANTI-SENSE: YES

35 (xi) SEQUENCE DESCRIPTION: SEQ ID NO:40:  
TTCTCGGAAC CTGGAGGAGC 20  
(2) INFORMATION FOR SEQ ID NO:41:

40 (i) SEQUENCE CHARACTERISTICS:  
(A) LENGTH: 20 base pairs  
(B) TYPE: nucleic acid  
45 (C) STRANDEDNESS: single  
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA (genomic)  
(iii) HYPOTHETICAL: NO  
50 (iv) ANTI-SENSE: YES

55 (xi) SEQUENCE DESCRIPTION: SEQ ID NO:41:  
GACACAGTAC CTTTGAAGTG 20  
(2) INFORMATION FOR SEQ ID NO:42:

60 (i) SEQUENCE CHARACTERISTICS:  
(A) LENGTH: 20 base pairs  
65 (B) TYPE: nucleic acid  
(C) STRANDEDNESS: single  
(D) TOPOLOGY: linear

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(ii) MOLECULE TYPE: DNA (genomic)  
(iii) HYPOTHETICAL: NO  
5 (iv) ANTI-SENSE: YES

10 (xi) SEQUENCE DESCRIPTION: SEQ ID NO:42:  
TGGACCAAAG CTGCAGAGGT 20

15 (2) INFORMATION FOR SEQ ID NO:43:  
(i) SEQUENCE CHARACTERISTICS:  
(A) LENGTH: 20 base pairs  
(B) TYPE: nucleic acid  
20 (C) STRANDEDNESS: single  
(D) TOPOLOGY: linear  
(ii) MOLECULE TYPE: DNA (genomic)  
25 (iii) HYPOTHETICAL: NO  
(iv) ANTI-SENSE: YES

30 (xi) SEQUENCE DESCRIPTION: SEQ ID NO:43:  
CCTCACCTGG CTGAAATAGA 20

35 (2) INFORMATION FOR SEQ ID NO:44:  
(i) SEQUENCE CHARACTERISTICS:  
(A) LENGTH: 20 base pairs  
40 (B) TYPE: nucleic acid  
(C) STRANDEDNESS: single  
(D) TOPOLOGY: linear  
(ii) MOLECULE TYPE: DNA (genomic)  
45 (iii) HYPOTHETICAL: NO  
(iv) ANTI-SENSE: YES

50 (xi) SEQUENCE DESCRIPTION: SEQ ID NO:44:  
AAGCACTCAC CTCCCAGGTG 20

55 (2) INFORMATION FOR SEQ ID NO:45:  
(i) SEQUENCE CHARACTERISTICS:  
(A) LENGTH: 20 base pairs  
60 (B) TYPE: nucleic acid  
(C) STRANDEDNESS: single  
(D) TOPOLOGY: linear  
(ii) MOLECULE TYPE: DNA (genomic)  
65 (iii) HYPOTHETICAL: NO

- 38 -

(iv) ANTI-SENSE: YES

5

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:45:

GACATTCTAC CTGCAGTTGA

20

10

(2) INFORMATION FOR SEQ ID NO:46:

(i) SEQUENCE CHARACTERISTICS:  
(A) LENGTH: 19 base pairs  
(B) TYPE: nucleic acid  
(C) STRANDEDNESS: single  
(D) TOPOLOGY: linear

15

(ii) MOLECULE TYPE: DNA (genomic)

20

(iii) HYPOTHETICAL: NO

(iv) ANTI-SENSE: YES

25

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:46:

CTCAAAAACC TATCAGAAA

19

30

(2) INFORMATION FOR SEQ ID NO:47:

(i) SEQUENCE CHARACTERISTICS:  
(A) LENGTH: 20 base pairs  
(B) TYPE: nucleic acid  
(C) STRANDEDNESS: single  
(D) TOPOLOGY: linear

35

(ii) MOLECULE TYPE: DNA (genomic)

40

(iii) HYPOTHETICAL: NO

(iv) ANTI-SENSE: YES

45

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:47:

GGAAACTTAC CTATCACTGT

20

50

(2) INFORMATION FOR SEQ ID NO:48:

(i) SEQUENCE CHARACTERISTICS:  
(A) LENGTH: 20 base pairs  
(B) TYPE: nucleic acid  
(C) STRANDEDNESS: single  
(D) TOPOLOGY: linear

55

(ii) MOLECULE TYPE: DNA (genomic)

60

(iii) HYPOTHETICAL: NO

(iv) ANTI-SENSE: YES

65

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(xi) SEQUENCE DESCRIPTION: SEQ ID NO:48:  
5 GCTAGCAAAA CTGAAAAGAG 20  
(2) INFORMATION FOR SEQ ID NO:49:  
10 (i) SEQUENCE CHARACTERISTICS:  
(A) LENGTH: 17 base pairs  
(B) TYPE: nucleic acid  
(C) STRANDEDNESS: single  
(D) TOPOLOGY: linear  
15 (ii) MOLECULE TYPE: DNA (genomic)  
(iii) HYPOTHETICAL: NO  
(iv) ANTI-SENSE: YES  
20  
(xi) SEQUENCE DESCRIPTION: SEQ ID NO:49:  
25 GAGAAATATT CATTCTG 17  
(2) INFORMATION FOR SEQ ID NO:50:  
30 (i) SEQUENCE CHARACTERISTICS:  
(A) LENGTH: 18 base pairs  
(B) TYPE: nucleic acid  
(C) STRANDEDNESS: single  
(D) TOPOLOGY: linear  
35 (ii) MOLECULE TYPE: DNA (genomic)  
(iii) HYPOTHETICAL: NO  
(iv) ANTI-SENSE: YES  
40  
(xi) SEQUENCE DESCRIPTION: SEQ ID NO:50:  
45 CGAGTCCTGA TAAAGCTG 18  
(2) INFORMATION FOR SEQ ID NO:51:  
50 (i) SEQUENCE CHARACTERISTICS:  
(A) LENGTH: 17 base pairs  
(B) TYPE: nucleic acid  
(C) STRANDEDNESS: single  
55 (D) TOPOLOGY: linear  
(ii) MOLECULE TYPE: DNA (genomic)  
(iii) HYPOTHETICAL: NO  
60 (iv) ANTI-SENSE: YES  
65  
(xi) SEQUENCE DESCRIPTION: SEQ ID NO:51:  
GATGAGGGTG CAAATAA 17

- 40 -

- (2) INFORMATION FOR SEQ ID NO:52:
- 5 (i) SEQUENCE CHARACTERISTICS:  
(A) LENGTH: 23 base pairs  
(B) TYPE: nucleic acid  
(C) STRANDEDNESS: single  
(D) TOPOLOGY: linear
- 10 (ii) MOLECULE TYPE: DNA (genomic)
- (iii) HYPOTHETICAL: NO
- 15 (iv) ANTI-SENSE: YES
- (xi) SEQUENCE DESCRIPTION: SEQ ID NO:52:
- 20 GGAGTGTAA TTAATAACAG TTT 23
- (2) INFORMATION FOR SEQ ID NO:53:
- 25 (i) SEQUENCE CHARACTERISTICS:  
(A) LENGTH: 19 base pairs  
(B) TYPE: nucleic acid  
(C) STRANDEDNESS: single  
(D) TOPOLOGY: linear
- 30 (ii) MOLECULE TYPE: DNA (genomic)
- (iii) HYPOTHETICAL: NO
- 35 (iv) ANTI-SENSE: YES
- (xi) SEQUENCE DESCRIPTION: SEQ ID NO:53:
- 40 CAGAGATTAC AAAACAAT 19
- (2) INFORMATION FOR SEQ ID NO:54:
- 45 (i) SEQUENCE CHARACTERISTICS:  
(A) LENGTH: 22 base pairs  
(B) TYPE: nucleic acid  
(C) STRANDEDNESS: single  
(D) TOPOLOGY: linear
- 50 (ii) MOLECULE TYPE: DNA (genomic)
- (iii) HYPOTHETICAL: NO
- 55 (iv) ANTI-SENSE: YES
- (xi) SEQUENCE DESCRIPTION: SEQ ID NO:54:
- 60 TGCCTTTTAA CATTTTCAAT CA 22
- 65 (2) INFORMATION FOR SEQ ID NO:55:
- (i) SEQUENCE CHARACTERISTICS:

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(A) LENGTH: 17 base pairs  
(B) TYPE: nucleic acid  
(C) STRANDEDNESS: single  
(D) TOPOLOGY: linear

5 (ii) MOLECULE TYPE: DNA (genomic)

(iii) HYPOTHETICAL: NO

10 (iv) ANTI-SENSE: YES

15 (xi) SEQUENCE DESCRIPTION: SEQ ID NO:55:  
ACACATAATT TAAAGGA 17

20 (2) INFORMATION FOR SEQ ID NO:56:

(i) SEQUENCE CHARACTERISTICS:  
(A) LENGTH: 17 base pairs  
(B) TYPE: nucleic acid  
(C) STRANDEDNESS: single  
25 (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA (genomic)

(iii) HYPOTHETICAL: NO

30 (iv) ANTI-SENSE: YES

35 (xi) SEQUENCE DESCRIPTION: SEQ ID NO:56:  
TTAAATTATT CAAAAGG 17

40 (2) INFORMATION FOR SEQ ID NO:57:

(i) SEQUENCE CHARACTERISTICS:  
(A) LENGTH: 20 base pairs  
(B) TYPE: nucleic acid  
45 (C) STRANDEDNESS: single  
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA (genomic)

50 (iii) HYPOTHETICAL: NO

(iv) ANTI-SENSE: YES

55 (xi) SEQUENCE DESCRIPTION: SEQ ID NO:57:  
AAGAGAAATA TTCATTCTG 20

60 (2) INFORMATION FOR SEQ ID NO:58:

(i) SEQUENCE CHARACTERISTICS:  
(A) LENGTH: 20 base pairs  
(B) TYPE: nucleic acid  
65 (C) STRANDEDNESS: single  
(D) TOPOLOGY: linear

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5 (ii) MOLECULE TYPE: DNA (genomic)  
(iii) HYPOTHETICAL: NO  
(iv) ANTI-SENSE: YES

10 (xi) SEQUENCE DESCRIPTION: SEQ ID NO:58:

CCCCCTCCCC CACCCCTGCA

20

15 (2) INFORMATION FOR SEQ ID NO:59:

20 (i) SEQUENCE CHARACTERISTICS:  
(A) LENGTH: 18 base pairs  
(B) TYPE: nucleic acid  
(C) STRANDEDNESS: single  
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA (genomic)

25 (iii) HYPOTHETICAL: NO

(iv) ANTI-SENSE: YES

30

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:59:

CTGCCGTGAT AATGCCCC

18

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**CLAIMS****We claim:**

- 5 1. An isolated nucleotide sequence encoding type 5  $17\beta$ -hydroxysteroid dehydrogenase, said sequence being sufficiently homologous to SEQ ID No. 1 or a complement thereof, to hybridize under stringent conditions to the coding region of SEQ ID No. 1 or a complement thereof and said sequence encoding an enzyme which catalyzes the conversion of progesterone to  $20\alpha$ -hydroxyprogesterone and the  
10 conversion of 4-androstenedione to testosterone.
2. The nucleotide sequence, as recited in claim 1, wherein said sequence is the coding region of SEQ ID No. 1.
- 15 3. A recombinant expression vector comprising a promoter sequence and a nucleotide sequence in accordance with claim 1.
4. A recombinant expression vector comprising a promoter sequence and a nucleotide sequence in accordance with claim 2.
- 20 5. A recombinant host cell, transformed or transfected with the vector of claim 4.
6. The recombinant host cell of claim 5, wherein said host cell is a eukaryotic cell.
- 25 7. A recombinant host cell, transformed or transfected with the vector of claim 3.
8. The recombinant host cell of claim 7, wherein said host cell is a eukaryotic cell.
- 30 9. The recombinant host cell of claim 8, wherein a nucleotide sequence that hybridizes under stringent conditions with SEQ ID No. 1 or its complement is integrated into the genome of said host cell.

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10. The recombinant host cell of claim 9, wherein said nucleotide sequence is located on a recombinant vector.
- 5 11. The recombinant host cell, as recited in claim 8, wherein said host cell is capable of expressing a biologically active type 5  $17\beta$ -hydroxysteroid dehydrogenase.
12. An isolated nucleotide sequence comprising at least ten consecutive nucleotides identical to 10 consecutive nucleotides in the coding region of SEQ ID No. 1, or the complement thereof.
- 10 13. The nucleotide sequence, as recited in claim 12, wherein said sequence comprises at least fifteen consecutive nucleotides identical to 15 consecutive nucleotides in the coding region of SEQ ID No. 1, or the complement thereof.
- 15 14. The nucleotide sequence, as recited in claim 13, wherein said sequence comprises at least twenty consecutive nucleotides identical to 20 consecutive nucleotides in the coding region of SEQ ID No. 1, or the complement thereof.
- 20 15. The nucleotide sequence, as recited in claim 13, wherein said sequence comprises at least thirty consecutive nucleotides identical to 30 consecutive nucleotides in the coding region of SEQ ID No. 1, or the complement thereof.
- 25 16. An oligonucleotide sequence selected from the group consisting of  
 TTTAGCTTTACACACTGCTGTT (SEQ ID No. 30),  
 TCCAAAGCTTTACTTCTCGG (SEQ ID No. 31), GATGAAAAGTGGACCA  
 (SEQ ID No. 32), ATCTGTTGGTGAAAGTTC (SEQ ID No. 33),  
 TCCAGCTGCCTGCGGT (SEQ ID No. 34), CTTGTACTTGAGTCCTG (SEQ ID  
 No. 35), CTCCGGTTGAAATACGGA (SEQ ID No. 36),  
 30 CATCGTTTGTCTCGTTGAGA (SEQ ID No. 37),  
 TCACTGTAAAATAGTGGAGAT (SEQ ID No. 38), and  
 ATCTGAATATGGATAAT (SEQ ID No. 39).

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17. An oligonucleotide sequence selected from the group consisting of  
 TTCTCGGAACCTGGAGGAGC (SEQ ID No. 40),  
 GACACAGTACCTTTGAAGTG (SEQ ID No. 41),  
 TGGACCAAAGCTGCAGAGGT (SEQ ID No. 42),  
 5 CCTCACCTGGCTGAAATAGA (SEQ ID No. 43),  
 AAGCACTCACCTCCCAGGTG (SEQ ID No. 44),  
 GACATTCTACCTGCAGTTGA (SEQ ID No. 45), CTCAAAAACCTATCAGAAA  
 (SEQ ID No. 46), GGAAACTTACCTATCACTGT (SEQ ID No. 47), and  
 GCTAGCAAACTGAAAAGAG (SEQ ID No. 48).
- 10
18. An oligonucleotide sequence selected from the group consisting of  
 GAGAAATATTCATTCTG (SEQ ID No. 49), CGAGTCCTGATAAAGCTG (SEQ  
 ID No. 50), GATGAGGGTGCAAATAA (SEQ ID No. 51),  
 GGAGTGTTAATTAATAACAGTTT (SEQ ID No. 52),  
 15 CAGAGATTACAAAAACAAT (SEQ ID No. 53),  
 TGCCTTTTTACATTTTCAATCA (SEQ ID No. 54), ACACATAATTTAAAGGA  
 (SEQ ID No. 55), TTAAATTATTCAAAGG (SEQ ID No. 56),  
 AAGAGAAATATTCATTTCTG (SEQ ID No. 57),  
 CCCCTCCCCCACCCTGCA (SEQ ID No. 58), and  
 20 CTGCCGTGATAATGCCCC (SEQ ID No. 59).
19. A recombinant expression vector comprising:  
 a promoter sequence; and  
 an oligonucleotide sequence selected from the group consisting of  
 25 TTTAGCTTTACACACTGCTGTT (SEQ ID No. 30),  
 TCCAAAGCTTTACTTCTCGG (SEQ ID No. 31), GATGAAAAGTGGACCA  
 (SEQ ID No. 32), ATCTGTTGGTGAAAGTTC (SEQ ID No. 33),  
 TCCAGCTGCCTGCGGT (SEQ ID No. 34), CTTGTACTTGAGTCCTG (SEQ ID  
 No. 35), CTCCGGTTGAAATACGGA (SEQ ID No. 36),  
 30 CATCGTTTGTCTCGTTGAGA (SEQ ID No. 37),  
 TCACTGTAAATAGTGGAGAT (SEQ ID No. 38), and  
 ATCTGAATATGGATAAT (SEQ ID No. 39).

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20. A recombinant expression vector comprising:  
a promoter sequence; and

an oligonucleotide sequence selected from the group consisting of

- TTCTCGGAACCTGGAGGAGC (SEQ ID No. 40),  
5 GACACAGTACCTTTGAAGTG (SEQ ID No. 41),  
TGGACCAAAGCTGCAGAGGT (SEQ ID No. 42),  
CCTCACCTGGCTGAAATAGA (SEQ ID No. 43),  
AAGCACTCACCTCCCAGGTG (SEQ ID No. 44),  
GACATTCTACCTGCAGTTGA (SEQ ID No. 45), CTCAAAAACCTATCAGAAA  
10 (SEQ ID No. 46), GGAACTTACCTATCACTGT (SEQ ID No. 47), and  
GCTAGCAAACTGAAAAGAG (SEQ ID No. 48).

21. A recombinant expression vector comprising:  
a promoter sequence; and

- 15 an oligonucleotide sequence selected from the group consisting of  
GAGAAATATTCATTCTG (SEQ ID No. 49), CGAGTCCTGATAAAGCTG (SEQ  
ID No. 50), GATGAGGGTGCAAATAA (SEQ ID No. 51),  
GGAGTGTTAATTAATAACAGTTT (SEQ ID No. 52),  
CAGAGATTACAAAAACAAT (SEQ ID No. 53),  
20 TGCCTTTTTACATTTTCAATCA (SEQ ID No. 54), ACACATAATTTAAAGGA  
(SEQ ID No. 55), TTAAATTATTCAAAAGG (SEQ ID No. 56),  
AAGAGAAATATTCATTTCTG (SEQ ID No. 57),  
CCCCTCCCCCACCCTGCA (SEQ ID No. 58), and  
CTGCCGTGATAATGCCCC (SEQ ID No. 59).

25

22. A method of blocking synthesis of type 5 17 $\beta$ -HSD. comprising the step of:

introducing an oligonucleotide selected from the group consisting of

- TTTAGCTTTACACACTGCTGTT (SEQ ID No. 30),  
TCCAAAGCTTTACTTCTCGG (SEQ ID No. 31), GATGAAAAGTGACCA  
30 (SEQ ID No. 32), ATCTGTTGGTGAAAGTTC (SEQ ID No. 33),  
TCCAGCTGCCTGCGGT (SEQ ID No. 34), CTTGTAAGTTCCTG (SEQ ID  
No. 35), CTCCGGTTGAAATACGGA (SEQ ID No. 36),  
CATCGTTTGTCTCGTTGAGA (SEQ ID No. 37),

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TCACTGTAAAAATAGTGGAGAT (SEQ ID No. 38), and  
ATCTGAATATGGATAAT (SEQ ID No. 39) into cells.

23. A method of blocking synthesis of type 5 17 $\beta$ -HSD, comprising the step of:
- 5 introducing an oligonucleotide selected from the group consisting of  
TTCTCGGAACCTGGAGGAGC (SEQ ID No. 40),  
GACACAGTACCTTTGAAGTG (SEQ ID No. 41),  
TGGACCAAAGCTGCAGAGGT (SEQ ID No. 42),  
CCTCACCTGGCTGAAATAGA (SEQ ID No. 43),  
10 AAGCACTCACCTCCCAGGTG (SEQ ID No. 44),  
GACATTCTACCTGCAGTTGA (SEQ ID No. 45), CTCAAAAACCTATCAGAAA  
(SEQ ID No. 46), GGAACTTACCTATCACTGT (SEQ ID No. 47), and  
GCTAGCAAACTGAAAAGAG (SEQ ID No. 48) into cells.
- 15 24. A method of blocking synthesis of type 5 17 $\beta$ -HSD, comprising the step of:  
introducing an oligonucleotide selected from the group consisting of  
GAGAAATATTCATTCTG (SEQ ID No. 49), CGAGTCCTGATAAAGCTG (SEQ  
ID No. 50), GATGAGGGTGCAAATAA (SEQ ID No. 51),  
GGAGTGTTAATTAATAACAGTTT (SEQ ID No. 52),  
20 CAGAGATTACAAAAACAAT (SEQ ID No. 53),  
TGCCTTTTTACATTTTCAATCA (SEQ ID No. 54), ACACATAATTAAAGGA  
(SEQ ID No. 55), TTAAATTATTCAAAAGG (SEQ ID No. 56),  
AAGAGAAATATTCATTTCTG (SEQ ID No. 57),  
CCCCTCCCCCACCCTGCA (SEQ ID No. 58), and  
25 CTGCCGTGATAATGCCCC (SEQ ID No. 59) into cells.

25. An isolated chromosomal DNA fragment which upon transcription and  
translation encodes type 5 17 $\beta$ -hydroxysteroid dehydrogenase and wherein said  
fragment contains nine exons and wherein said fragment includes introns which are 16  
30 kilobase pairs in length.

26. An isolated DNA sequence encoding type 5 17 $\beta$ -hydroxysteroid  
dehydrogenase, said sequence being sufficiently homologous to SEQ ID No. 3 or a

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complement thereof, to hybridize under stringent conditions to SEQ ID No. 3, or its complement.

27. A method for producing type 5 17 $\beta$ -hydroxysteroid dehydrogenase, comprising  
5 the steps of:

preparing a recombinant host transformed or transfected with the vector of claim 3; and

culturing said host under conditions which are conducive to the production of type 5 17 $\beta$ -hydroxysteroid dehydrogenase by said host.

10

28. A method for determining the inhibitory effect of a test compound on the enzymatic activity of type 5 17 $\beta$ -hydroxysteroid dehydrogenase, comprising the steps of:

providing type 5 17 $\beta$ -hydroxysteroid dehydrogenase;

15 contacting said type 5 17 $\beta$ -hydroxysteroid dehydrogenase with said test compound; and thereafter

determining the enzymatic activity of said type 5 17 $\beta$ -hydroxysteroid dehydrogenase in the presence of said test compound.

20 29. The method, as recited claim 28, wherein said step of determining enzymatic activity includes the steps of:

adding a substrate which is metabolized by said type 5 17 $\beta$ -hydroxysteroid dehydrogenase; and

determining an amount of said substrate which is converted to metabolite.

25

30. A method of interfering with the expression of type 5 17 $\beta$ -hydroxysteroid dehydrogenase, comprising the step of administering nucleic acids substantially identical to at least 15 consecutive nucleotides of SEQ ID No. 1 or a complement thereof.

30

31. A method of interfering with the synthesis of type 5 17 $\beta$ -hydroxysteroid dehydrogenase, comprising the step of administering antisense RNA complementary to mRNA encoded by at least 15 consecutive nucleotides of SEQ ID No. 1 or a

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complement thereof.

32. A method of interfering with the expression of type 5 17 $\beta$ -hydroxysteroid dehydrogenase, comprising the step of administering nucleic acids substantially  
5 identical to at least 15 consecutive nucleotides of SEQ ID No. 3 or a complement thereof.

33. A method of interfering with the synthesis of type 5 17 $\beta$ -hydroxysteroid dehydrogenase, comprising the step of administering antisense RNA complementary  
10 to mRNA encoded by at least 15 consecutive nucleotides of SEQ ID No. 3 or a complement thereof.

34. A method for determining the inhibitory effect of antisense nucleic acids on the enzymatic activity of type 5 17 $\beta$ -hydroxysteroid dehydrogenase, comprising the steps  
15 of:

providing a host system capable of expressing type 5 17 $\beta$ -hydroxysteroid dehydrogenase;

introducing said antisense nucleic acids into said host system; and thereafter

determining the enzymatic activity of said type 5 17 $\beta$ -hydroxysteroid  
20 dehydrogenase.

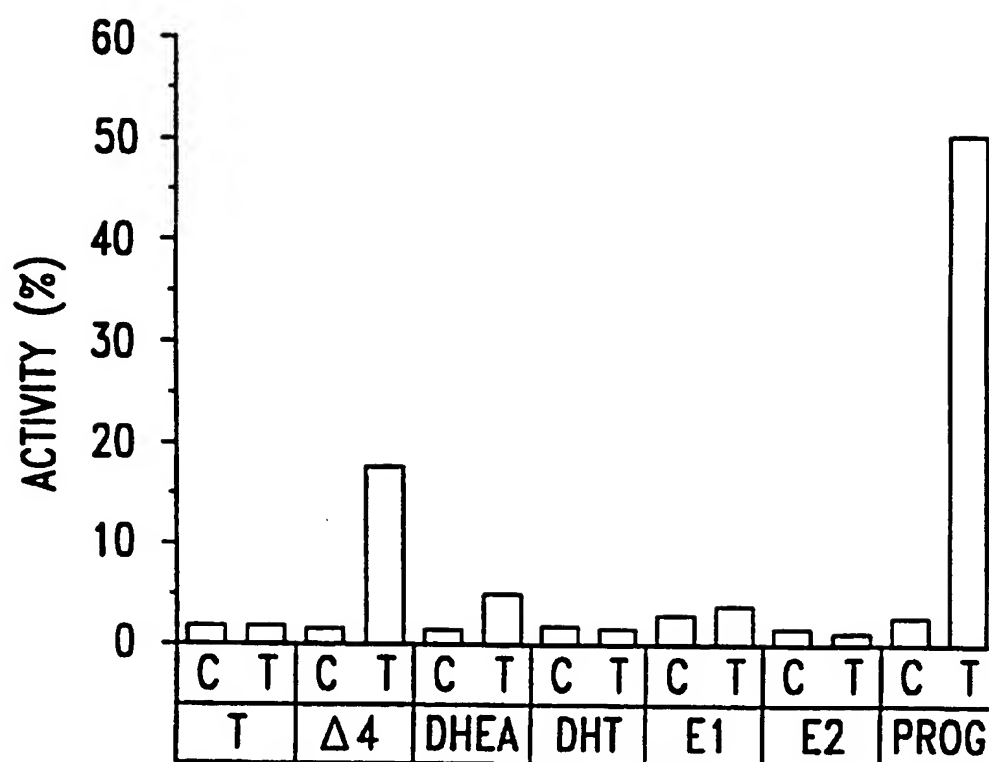


FIG. 1A

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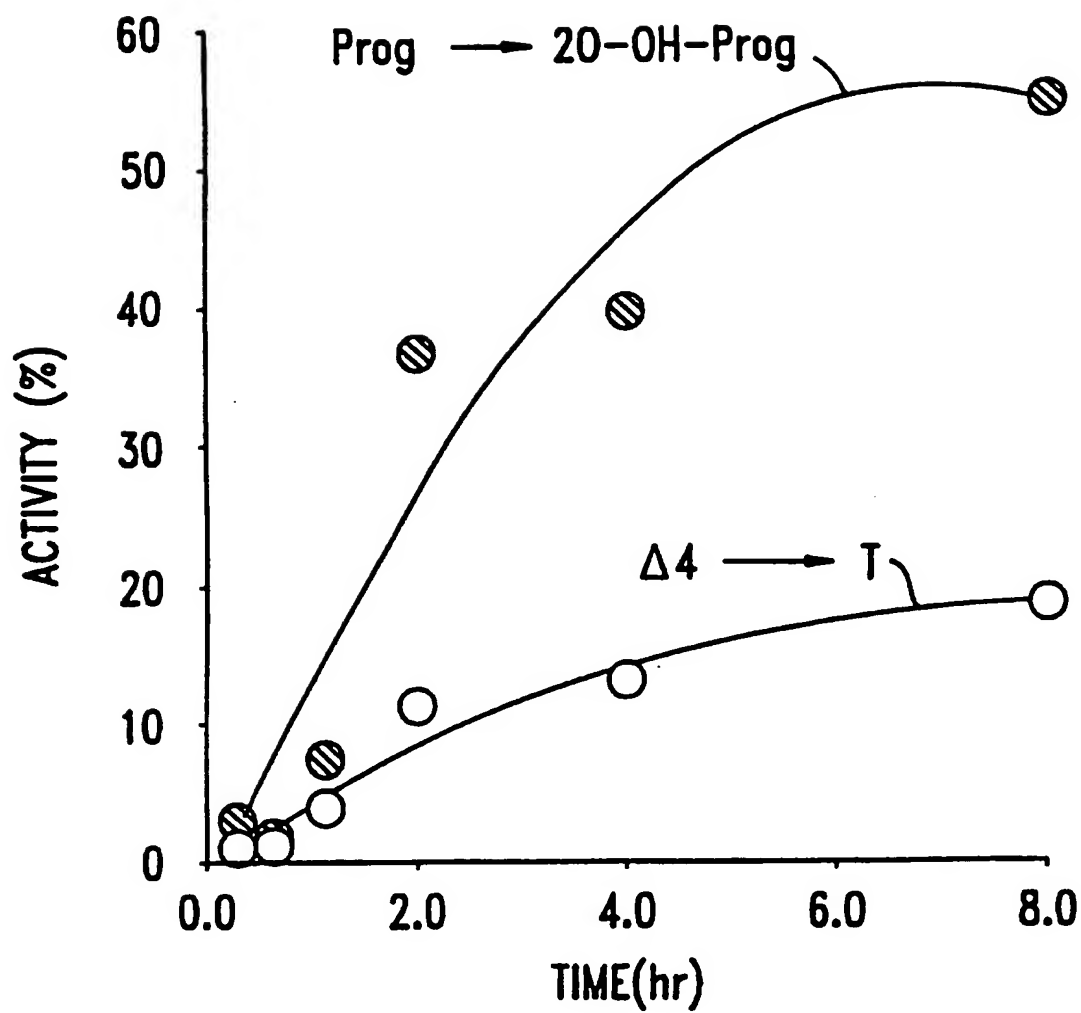
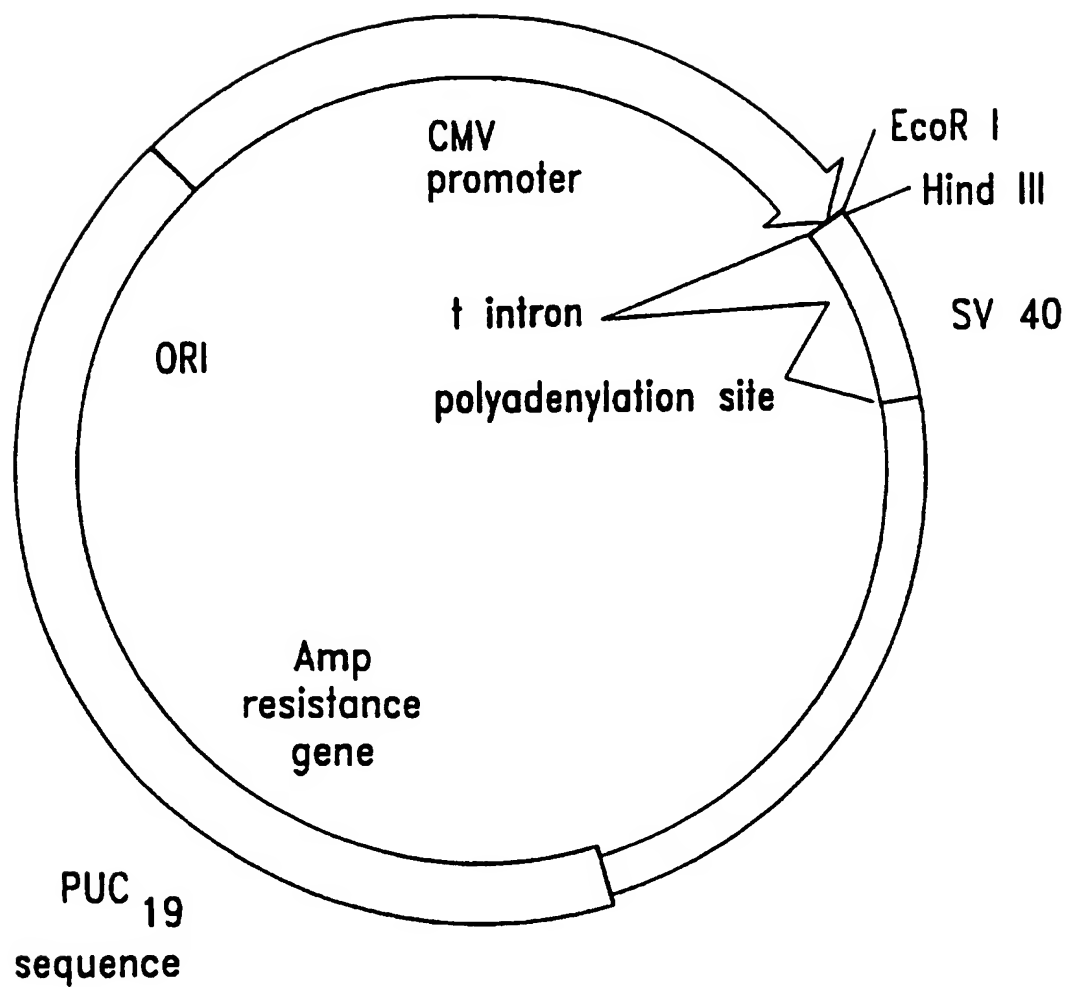


FIG. 1B



**FIG. 2**

GTGACAGGGA	ATG	GAT	TCC	AAA	CAG	CAG	TGT	GTA	AAG	CTA	AAT	GAT	GGC	49
	Met	Asp	Ser	Lys	Gln	Gln	Cys	Val	Lys	Leu	Asn	Asp	Gly	
CAC	TTC	ATG	CCT	GTA	TTG	GGA	TTT	GGC	ACC	TAT	GCA	CCT	CCA	97
His	Phe	Met	Pro	Val	Leu	Gly	Phe	Gly	Thr	Tyr	Ala	Pro	Pro	
													Glu	Val
CCG	AGA	AGT	AAA	GCT	TTG	GAG	GTC	ACC	AAA	TTA	GCA	ATA	GAA	145
Pro	Arg	Ser	Lys	Ala	Leu	Glu	Val	Thr	Lys	Leu	Ala	Ile	Glu	
													Ala	Gly
TTC	CGC	CAT	ATA	GAT	TCT	GCT	CAT	TTA	TAC	AAT	AAT	GAG	GAG	193
Phe	Arg	His	Ile	Asp	Ser	Ala	His	Leu	<del>Tyr</del>	Asn	Asn	Glu	Glu	
									<del>TSK</del>				Val	
GGA	CTG	GCC	ATC	CGA	AGC	AAG	ATT	GCA	GAT	GGC	AGT	GTG	AAG	241
Gly	Leu	Ala	Ile	Arg	Ser	Lys	Ile	Ala	Asp	Gly	<del>Ser</del>	Val	Lys	
											<del>PKC</del>		Arg	Glu
GAC	ATA	TTC	TAC	ACT	TCA	AAG	CTT	TGG	TCC	ACT	TTT	CAT	CCA	289
Asp	Ile	Phe	Tyr	<del>Thr</del>	Ser	Lys	Leu	Trp	Ser	Thr	Phe	His	Arg	
				<del>PKC</del>									Pro	Glu
TTG	GTC	CGA	CCA	GCC	TTG	GAA	AAC	TCA	CTG	AAA	AAA	GCT	CAA	337
Leu	Val	Arg	Pro	Ala	Leu	Glu	Asn	Ser	Leu	Lys	Lys	Ala	Gln	
													Leu	Asp

FIG. 3A-1

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385 TAT GTT GAC CTC TAT CTT ATT CAT TCT CCA ATG TCT CTA AAG CCA GGT  
 Tyr Val Asp Leu Tyr Leu Ile His Ser Pro Met Se PKC  
 433 GAG GAA CTT TCA CCA ACA GAT GAA AAT GGA AAA GTA ATA TTT GAC ATA  
 Glu Glu Leu Se CK2 CK2 Thr Pro Thr Asp Glu Asn Gly Lys Val Ile Phe Asp Ile  
 481 GTG GAT CTC TGT ACC ACC TGG GAG GCC ATG GAG AAG TGT AAG GAT GCA  
 Val Asp Leu Cys Th CK2 Thr Thr Trp Glu Ala Met Glu Lys Cys Lys Asp Ala  
 529 GGA TTG GCC AAG TCC ATT GGG GTG TCA AAC TTC AAC CGC AGG CAG CTG  
 Gly Leu Ala Lys Ser Ile Gly Val Ser Asn Phe Asn Arg Arg Gln Leu  
 577 NM Aldo/keto reductase family signature 1  
 GAG ATG ATC CTC AAC AAG CCA GGA CTC AAG TAC AAG CCT GTC TGC AAC  
 Glu Met Ile Leu Asn Lys Lys Pro Gly Leu Lys Tyr Lys Pro Val Cys Asn  
 625 CAG GTA GAA TGT CAT CCG TAT TTC AAC CCG AGT AAA TTG CTA GAT TTC  
 Gln Val Glu Cys His Pro Tyr Phe Asn NG Arg Ser Lys Leu Leu Asp Phe  
 673 TGC AAG TCG AAA GAT ATT GTT CTG GTT GCC TAT AGT GCT CTG GGA TCT  
 Cys Lys Ser Lys Asp Ile Val Leu Val Ala Tyr Ser Ala Leu Gly Se PKC  
 721 CAA CGA GAC AAA CGA TGG GTG GAC CCG AAC TCC CCG GTG CTC TTG GAG  
 Gln Arg Asp Lys Arg Trp Val Asp Pro Asn Ser Pro Val Leu Leu Glu

FIG. 3A-2

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GAC CCA GTC CTT TGT GCC TTG GCA AAA AAG CAC AAG CGA ACC CCA GCC 769  
 Asp Pro Val Leu Cys Ala Leu Ala Lys Lys His Lys Arg Thr Pro Ala  
 CTG ATT GCC CTG CGC TAC CAG CTG CAG CGT GGG GTT GTG GTC CTG GCC 817  
 Leu Ile Ala Leu Arg Tyr Gln Leu Gln Arg Gly Val Val Val Leu Ala  
 Aldo/Keto reductase family  
 AAG AGC TAC AAT GAG CAG CGC ATC AGA CAG AAC GTG CAG GTT TTT GAG 865  
 Lys Ser Tyr Asn Glu Gln Arg Ile Arg Gln Asn Val Gln Val Phe Glu  
 CK2 signature 2  
 TTC CAG TTG ACT GCA GAG GAC ATG AAA GCC ATA GAT GGC CTA GAC AGA 913  
 Phe Gln Leu Thr Ala Glu Asp Met Lys Ala Ile Asp Gly Leu Asp Arg  
 AAT CTC CAC TAT TTT AAC AGT GAT AGT TTT GCT AGC CAC CCT AAT TAT 961  
 Asn Leu His Tyr Phe Asn Ser Asp Ser Phe Ala Ser His Pro Asn Tyr  
 CCA TAT TCA GAT GAA TAT TAA CATGGAGACT TTGCCTGATG ATGTCTACCA 1012  
 Pro Tyr Ser Asp Glu Tyr \*  
 GAAGGCCCTG TGTGTGGATG GTGACGCAGA GGACGTCTCT ATGCCGGTGA CTGGACATAT 1072  
 CACCTCTACT TAAATCCGTC CTGTTTAGCG ACTTCAGTCA ACTACAGCTC ACTCCATAGG 1132  
 CCAGAAATAC AATAAATCCT GTTTAGCGAC TTCAGTCAAC TACAGCTCAC TCCATAGGCC 1192  
 AGAAATACAA TAAA 1206

FIG. 3A-3

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h 20αHSD      MDSKQQCVKLNKGHMPVLGFGTYAPPEVPRSKALEVTKLAIEAGFRHIDSALHY 55
rb20αHSD      --P-F-R-A-S-----I-----E---K---M-A--I--D-----YF-
r 20αHSD      -N--I-KME-----SI-----TE-NL-K-SM-S--I--DV-----CS--
b 20αHSD      . . . . . -AK--I--L--WKS-PGKYTE-VK-AIDLGY. . . . . -C-V-
h 3αHSD      --P-Y-R-E-----NR-V-----Y--
r 3αHSD      ---ISLR-A---N-I-----TV-EK-AKDEVIKA--I--DN---F---Y--
b pgfs        --P-S-R-----I-----E---K-E---A--F---V---V---
f ρ-crys      TLT-ETR-T---NM--I--L---S-H--K-L-E-AV-I--DV-Y---C-FIT

h 20αHSD      NNEQVGLAIRSKIADGSVKREDIFYTSKLWSTFHRPELVRPALENSLKKAQLDY 110
rb20αHSD      K--KE-----T-----C-----S--D---NL---
r 20αHSD      Q---EI-Q-V---E--T-----S-----S---R-LN---
b 20αHSD      Q--NE---LQA-LQEKV---L-IV---C-Y-DKD--KG-CQKT-SDLK---
h 3αHSD      -----FQ-QM-Q---S---L---
r 3αHSD      EV--E-Q---E--T-----TC--KT--ST---
b pgfs        Q-----Q-----T-----CNSLQ-----K--QNL---
f ρ-crys      G--MHI-NG---S--T-----G---C-YFS--M--KG--R--RDVGM--

h 20αHSD      VDLYLIHSPMSLKPGEELSPTDENGKVI FDI VDLCTTWEAMEKCKDAGLAKSIGV 165
rb20αHSD      ---I--F-TA---V-II---H--A---T--I-A-----
r 20αHSD      ---F-V---D--L-Q--H-NL-L-T---D-----
b 20αHSD      L-----W-TGF---KDFF-L--D-N--PSEK-FVD--T---ELV-E--V-A---
h 3αHSD      ---L-F--A---TPL-K-----T---SA---V-----
r 3αHSD      ---I--F--A-Q---DIFF-R--H--LL-ET--I-D-----
b pgfs        ---I---V-----NKFV-K--S--L---S---H---L---T---
f ρ-crys      L--F-M-W-V-----SGASD-S-KDKPF-Y-N-----A-----L-AR-----VR-L--

```

FIG. 4A-1

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<b>h 20αHSD</b>	SNFNRRQLEMILNKPGLKYPVCNQVECHPYFNRSKLLDFCKSKDIVLVAYSALG	220
<b>rb20αHSD</b>	-----L-QG-----E-----G-----	
<b>r 20αHSD</b>	-----K-----HR-----L-L-Q-----AY--MN-----G-----	
<b>b 20αHSD</b>	-----HL-V-K-----AV-I-----LTQE--IQY-N-G--VT--P--	
<b>h 3αHSD</b>	-----C-----L-Q-----H-----	
<b>r 3αHSD</b>	-----C-----R-----L-L-QG-M--Y-----I--S-CT--	
<b>b pgfs</b>	-----HK-----K-----L-Q-----E-----H-----A-----	
<b>f ρ-crys</b>	-----R-----R-----V-L-QN--HSY-----T--V--	
<b>h 20αHSD</b>	SQDKRWVDPNSPVLLDPVLCALAKKHKRTPALIALRYQLQRGVVVLAKSYNEQ	275
<b>rb20αHSD</b>	-H-EPE--QSA-----LIG-----QQ-----I-----FT-K	
<b>r 20αHSD</b>	T--Y-YCINEDT--D--I--TM--YQ-----E--I-T-V--F--E	
<b>b 20αHSD</b>	-P-RP-AK-ED-SI-----RIK-I-D-YNK-T-QVLI-FPI--NLI-IP--VTPE	
<b>h 3αHSD</b>	T--HKL-----	
<b>r 3αHSD</b>	-S--T--OK-----D-----I--Y-Q-----V-----P-IR-F-AK	
<b>b pgfs</b>	A-LLSE--NS-N-----I-----Q-----V-----F-KK	
<b>f ρ-crys</b>	-H--RN--LSL-----D--I-NKV-A-YN--S-E--M-FI--KQI-----FTPA	
<b>h 20αHSD</b>	RIRQNVQVFEFQLTAEDMKAIDGLDRNLHYFNSDSFASHPNYPYSDEX	323
<b>rb20αHSD</b>	--KE-I-----PS-----V--S-N--FR-VTA-FAIG-----F-----	
<b>r 20αHSD</b>	---E-L---D---ASD---ELL-N-----R--PANM-KA---F-F-----	
<b>b 20αHSD</b>	--AE-F---D-E-DK---NT-LSYN-DWRACALV-C---RD--FHE-F	
<b>h 3αHSD</b>	---E-----S-----VL---N--YR-VVM-FLMD--D--F-----	
<b>r 3αHSD</b>	--KELT-----AS-----L---N--FR-N-AKY-DD---H-FT--	
<b>b pgfs</b>	--KE-M---D-E-P-----N--IR-YDFQKGIG--E--F-E--	
<b>f ρ-crys</b>	--K--LG---E-KP---SLES-----GPFREVKQ--E--FH---	

FIG. 4A-2

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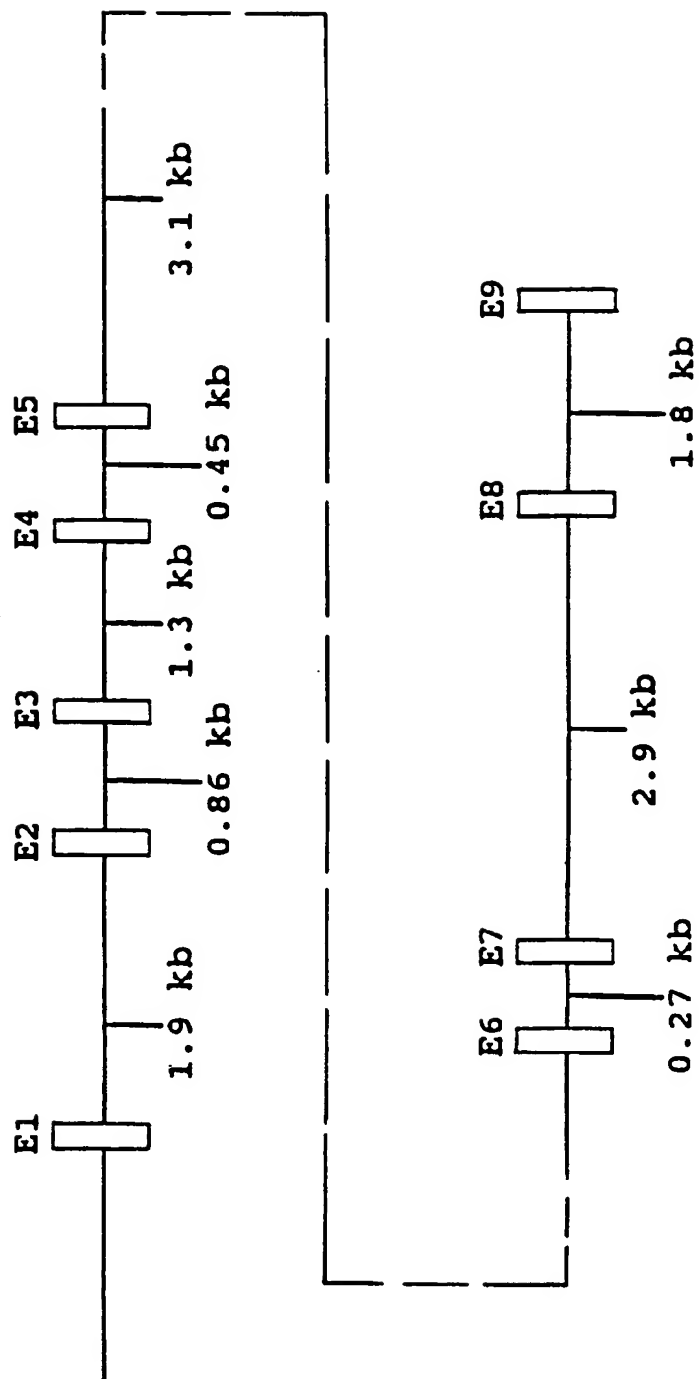


FIG. 5

AAGAACAAATACTATTAAAGGCACTGCTTGCCATATATTAAATGATGTCCAAACTCCAAAACTGTAAATAATTAAACACTCC  
 AATAAAACACTACACCAGAAATTTCTTTTATTGTCACCCCTCATCAGGATTACAGCTTTATCAGGACTGCACTCTTCTTCAGA  
 AATGAATATTCTCTTACAAACGCAAGAAAGAAATCAAAATAAAATTTCTGATTTGAAATGTAAAGGCAAAATATTTT  
 TTACAGTTTAACTTTAAATTTTATTGAGGACCAACTGTTTGAATAATCTCATTAGTCATTCCTTTTAAATATATGTGTA  
 TGTGAGAGAAAGACGTAAGATGGTTAATTATTCAAAATGATGCAGTATAAAGAGGGGCATTTATCAGGCAGAAACGAAA  
 AAAGATATTGTAGCTGGAGGTTTATAGTCTAACAATATGTTGCTATTGTTCTACAAATCCTTTTGAATAATTAAAT  
 ATAGAGATTTTCGAATAGAAATAATACTTTAGATAGAAATTAATGAGTTTATATAACCATATATTATAATAATTACTT  
 AGGAATTCCTTTGATAGAAACAAATGAATGCAATTTTCTCCACAGACCATATAAGACTGCCTATGTACCTCCT  
 CCTACATGCCATTGGTTAACCATCAGTCAGTTGTCAGGGGTGGGGGAGGGGTTTCTGCCCATTTGTTTGTAAATCTCT  
 GAGGAGAAGC

AGCAGCAAAACATTGTGCTAGTCAGACAAGTGACAGGGA

Met Asp Ser Lys Gln Gln Cys Val Lys Leu Asn Asp Gly His Phe Met Pro Val Leu Gly  
 ATG GAT TCC AAA CAG CAG TGT GTA AAG CTA AAT GAT GAT GGC CAC TTC ATG CCT GTA TTG GGA  
 Phe Gly Thr Tyr Ala Pro Pro Glu  
 TTT GGC ACC TAT GCA CCT CCA GAG

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GTAAGAATAATTCCTTTTAGTTTTTCGGATTTTCAAAAGAAATAAACCTAGTAGAGTGAAACCCGTTATTGGGTTGTAAAGGTT  
 CGTGTTCCTACCTTACTCTGGATGACTCACTGGTCTAGGTTTCTTAGGCTAGGAGAGAAAGTAGGCAATCCTTGTCTG  
 CATTGAGGTCCATTCCCTATGGTCACGTAAGTTTTCGTTTGTGCACTGTTTCTTCTTCTTCTGTTCTCATGTCTAGTTC  
 CCAGCTTGGCAG.....1.2 kb.....GGAAGTCTGAGTGAGCAATCTGTGTAATATCACTGGGAGAG  
 AACTCATATGAGCTTGCACCGTTTCCCTTCTATATCTCCATGTGATTTTACCATGTATAATATCACTATATTAATAAATAA  
 TTAGGACTATTTTCAGTCAATGTTAACTTTTCCAAACAATCACTGAATCTGAGGGTGTATGTGGTACCTCCATACAGTGA  
 TCAACCAGAGATTGCCCTGAGACTGAAGGTGTTCTGGGATGCTCAACCTTTATTAATACTAACGAGAAAGACTCAGGCCAAAC  
 TGAGATGGACTTTTCAACCCCATACAGACAGGAGGAAAGCTGATTTCTTGTATATAAAGTCAATGTCTTGTGCTGAACTA  
 CCTCTCAGCCACAGTGATCACCCAGATACTACCTTTGGTGTCTCCTCCAG

FIG. 6A-1

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Val Pro Arg Ser Lys Ala Leu Glu Val Thr Lys Leu Ala Ile Glu Ala Gly Phe Arg His  
 48  
 GTT CCG AGA AGT AAA GCT TTG GAG GTC ACA AAA TTA GCA ATA GAA GCT GGG TTC CGC CAT  
 68  
 Ile Asp Ser Ala His Leu Tyr Asn Asn Glu Gln Val Gly Leu Ala Ile Arg Ser Lys  
 ATA GAT TCT GCT CAT TTA TAC AAT AAT GAG GAG CAG GTT GGA CTG GCC ATC CGA AGC AAG  
 84  
 Ile Ala Asp Gly Ser Val Lys Arg Glu Asp Ile Phe Tyr Thr Ser Lys  
 ATT GCA GAT GGC AGT GTG AAG AGA GAA GAC ATA TTC TAC ACT TCA AAG

GTACTGTCTATGATGAGCTTGTGTGCACATGTATTATTGTGATTTGTGTGAGATGACAATTTCTATGACTGGATGAGT  
 AGTTGTGGGTGAATTTTGGCTTCTGGGTTCAAAATTTATTTCACACATACCTACATACTAAACTGAAATCAAAATCAAGGAA  
 TGATGATCAGCTTTTCAATTTTGGCTGTGTCCAAATTTATGACCTGAAAGTCCCTTTACTTTTGTAGCTTCAGCCGAGATC  
 AGTGTGATTTGACATGTGCTATAGAAATCACAGAGAACAAATATCATGTTATGTTTCTTATCGCTGGGTGATTTTCT  
 AAGATTTCTTATTATTCTCTCAATTGCTATCTTTATCAGTGAGATAGAAAGCAATATAAGAAAGCTCTGGGAGTATTAAA  
 TAATAGACACTTAAATTTGTCCTAAATTTGTCCAGCATAGTGAGCATGTTCAAAACTTGTTTTACCCCTTTTATGTTG  
 CTTTAGTTTCTAAGCAACATAAATAGCTATTCTTAAGCATTTGGTTGAATGGATAGAAATTAGACTGTAAATGAGT  
 TGTAAACTCTACTGAAGATAATTTCAGGTAACATCATAGTTATTACTTAATACTAATCTTTACATTTTAAGAAATTTACTCC  
 TATCATTCAGTAGATGTACAAACTATACATCCAACTGATATAAAGTTTATAAGGATAGG.....0.1 kb.....  
 ACTAGATGGCACAAAGTAATAAGATTGTGCTCAAGCATTCATTCAAAATCACTCCATTCTTTAACCTCTGCAG

FIG. 6A-2

GTGAGTGTGCGGAGGACACAGAGAGGATGACAAAGAGAAATCTGTTCCAGGTTCGATAGGAAAGAAATGG  
AAATATGCACCATTAGATC.....0.1 kb.....GACAGGAATCTCTTCTCTGCTTGTGCATTAATCTAT  
GCAGTTTCTAAGGAAGAGATAGAAATCTTACTCTTGCTGCTCTATCTTCTCCCTATTGCTGTTGAAATTTTCT  
TTTTTTGACAAATCACTGCTAGCTATTTTCATTGTGCATCTTGAAGTTGTTGCTCTCACAGTCTGTCTTGCAATTACC  
GTGATTTGCAGCCAACTGCACAAATAATTCCTCAACCCCTTTCTCCACAG

**FIG. 6A-3**

169 Ala Met Glu Lys Cys Lys Asp Ala Gly Leu Ala Lys Ser Ile Gly Val Ser Asn Phe Asn  
 GCC ATG GAG AAG TGT AAG GAT GCA GGA TTG GCC AAG TCC ATT GGG GTG TCA AAC TTC AAC  
 189 Arg Arg Gln Leu Glu Met Ile Leu Asn Lys Pro Gly Leu Lys Tyr Lys Pro Val Cys Asn  
 CGC AGG CAG CTG GAG ATG ATC CTC AAC AAG CCA GGA CTC AAG TAC AAG CCT GTC TGC AAC  
 190 Gln  
 CAG  
 GTGAGCTCCCTTGGCCCTTCTCTCCTTTCGGTTCTTTCATGCCCCCTCTTCCCTGTCCCTATTGCCAAATATCTGTTTGT  
 GTCCCAAGTTATCTTGTGAAGTAGAAGATTATCTAGAGAGCAAGCTTCTGTCAAGAA.....2.8 kb  
 .....ATTTCATTATATCTTTAGAGATATATAAATTTATTTCTATGAAAAGGTTATT  
 ACTTGACAAATAATCCTCAGCTCAAAATATATGCTATCTGATTATTATTCAGCTTCCCTTACTTTCATCTTTTCAATA  
 TTAACATAACTATTTCATATAAATTGATGCTTCTCTTTTGGTCAACTGCAG  
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 Val Glu Cys His Pro Tyr Phe Asn Arg Ser Lys Leu Leu Asp Phe Cys Lys Ser Lys Asp  
 210 GTA GAA TGT CAT CCG TAT TTC AAC CGG AGT AAA TTG CTA GAT TTC TGC AAG TCG AAA GAT  
 Ile Val Leu Val Ala Tyr Ser Ala Leu Gly Ser Gln Arg Asp Lys Arg Tr  
 227 ATT GTT CTG GTT GCC TAT AGT GCT CTG GGA TCT CAA CGA GAC AAA CGA TG  
 GTAATAAAACAATGGGACCTTTACATAAAACCTTTCATTTTGCAGAAAAATTTTATTAGTCAGAGCATCCTCAGTTTCCCTGT  
 AGTTAAGTTTCAAGTGGCTCATGGAGAGGAAAGAGAATTGCGTTTCTGACGAGATCT.....0.1 kb....  
 .....TTTAGGGAGCTGCCCTAACAACTATCGGCAGCCTCAGGGCCTTCTGCGCTTTCCTTCCAG

FIG. 6B-1

p Val Asp Pro Asn Ser Pro Val Leu Leu Glu Asp Pro Val Leu Cys Ala Leu Ala Lys 246  
 G GTG GAC CCG AAC TCC CCG GTG CTC TTG GAG GAC GAC CCA GTC CTT TGT TGT GCA AAA  
 Lys His Lys Arg Thr Pro Ala Leu Ile Ala Leu Arg Tyr Gln Leu Gln Arg Gly Val Val 266  
 AAG CAC AAG CGA ACC CCA GCC CTG ATT GCC CTG CTG CGC TAC CAG CTG CAG CGT GGG GTT GTG  
 Val Leu Ala Lys Ser Tyr Asn Glu Gln Arg Ile Arg Gln Asn Val Gln 282  
 GTC CTG GCC AAG AGC TAC AAT GAG CAG CGC ATC AGA CAG AAC GTG CAG  
  
 GTGAGGAGCGGGCTGTGGCCCTCAGGTCTCCTGCACAGTGTCCTTCACACGTTGTGCTTCTGTAAAGGCTCTCAGGACA  
 GCCTTGGGCCAGCTCCATTTCCTGTATTTCCCATATGAATGCTTTGGTGCACTCCT.....2.5.....  
 .....CCCTATCATGTGGGCACAATGTCAGCGCTGTTCTTCTCCATTTCCTGTGAAATTTTCTCTTTGTCTGTC  
 AGAGTTGCACAGTTTCAATACATAATATCTAGGAATGGATTCTGCTTATTTTCGTGAGCTATTTCATGACCCACCTG  
 AGTGTTTAGAGCTGACTTCTATAACTGTTTAAACCTTACCAATATTTAAGTATTGTCTCTGCACCCCTACTGTCTAATA  
 TACTTGGGGATTCAACAACCTGGCAATCTAAAAATAATAAAGTTTATTATTCTGATAG  
  
 Val Phe Glu Phe Phe Gln Leu Thr Ala Glu Asp Met Lys Ala Ile Asp Gly Leu Asp Arg Asn 302  
 GTT TTT GAG TTC CAG TTG ACT GCA GAG GAC ATG AAA GCC ATA GAT GGC CTA GAC AGA AAT  
 Leu His Tyr Phe Asn Ser Asp Se  
 CTC CAC TAT TTT AAC AGT GAT AG 310

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FIG. 6B-2

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GTAAGTTTCCTTTGTAAATGGGTGATCTAAATTTATTTCTGGAGAAAGGAATGTAGGATGGGTGTGAGAGTGACCTCCATA  
 CCAGAGGGACAGAGGCCAATGTGAGTCAGAGGTGAGACTGGAACCTCTCCTGCTGGATTCACTCCAGAGCTCTGTTCTCTG  
 GCAGGGTGAGTGGCAGGATCAGCATGGGTCAACCTGTGCTCTGCTCTGCTGACCTCCATGGAACTTTCCAGAGCAGCC  
 AACATCATTCGCCAAGCTGCACGTTCCATATAGGCCCTGGTGTCTTCTACCACTGGACATGCTGTGGATACTGCCCATGTGA  
 CTTCAATTAGATGTTTCCAAATCTGTGCTTATATACATTTGTCCTCCAAACCTGCTCAGCTCTTATCAAAATCAAAACATTT  
 CCATCAACTTTGTGGTCCAGGTGCCAATTTCCACCTCTTCATATGGAAATGCTTGTCTAGATCCTGTCAATTCAGCATCT  
 TTTATTAATTTCAAAATGTTTCTCTCTCTGCACTGTTGTCATGCCCCAACTCTGCTTTTGGCTCCAGAAAGCC  
 TTCCTTAGTGGAGTGAATAGGAGTGCTTGTCTTGTATTCCTGCAATATGGAGCTCTCAAGGCAGAGAAATTTTAAAAAAT  
 TTAAAAATCAAGGAGTGTGAGTGTGGAGGCAGAGCTCCATTTGTGTATATAATTTGTAGCTGATAAAAGATCT.....  
 ..2.7 kb.....TTTAATGCACCTGTAGCTCCTTGGATATTAGACCTATATCATATATAACAATTTACATTTCTG  
 AATCTTACAAAATATATTGCATACAGTAGGCAGTAGCAAGTAATAAGTAAGTAACAAGAAAGTATAATCAGAGTATC  
 TCTGCTCTGCTGACAGATGTACAGGAATATACTTGAATATTGACTTGTGTGTTTACGTTGTTAACTTCCAGATAAGGG  
 AATATGATTGAATAAATTTATTTTGAATAATACTGTATTATGAAGCCATGTTTCATAAAGGTAAGAAAGGCAGATTCTAC  
 AACTAGTCAGACAACTTAACATTCATATACTAATGACAGCTTCATTGAAATCACTTTACTACTCCCTAGTAATGGAGTCAT  
 TGCATTTATATTATACATTATTCTCTTTTCAG

r Phe Ala Ser His Pro Asn Tyr Pro Tyr Ser Asp Glu Tyr End  
 T TTT GCT AGC CAC CCT AAT TAT CCA TAT TCA GAT GAA TAT TAA

CATGGAGGGCTTTGCCCTGATGTCTACCAAGAGGCCCTGTGTGGATGGTGACGCAGAGGACGTCTCTATGCCGGTG  
 ACTGGACATATCACCTCTACTTAAATCCGTCCTGTTTAGCGACTTCAGTCAACTACAGCTGAGTCCATAGGCCAGAAAGA  
 CAATAAAATTTTATCATTTTGAATAA

TTGAATGTTTCTCAAGAATTTCTTTACCTACTCTGTTCTGTAGTGTGTGTTTCTTCTGGCTCAGAAAGTGTGTGTGTG  
 TGTGTGTGCTTTCTTCTGCTCAACAGG

FIG. 6B-3

# INTERNATIONAL SEARCH REPORT

1. National Application No  
PCT/CA 96/00605

A. CLASSIFICATION OF SUBJECT MATTER  
IPC 6 C12N9/04

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)  
IPC 6 C12N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CLINICAL AND INVESTIGATIVE MEDICINE, vol. 18, no. sup.4, September 1995, TORONTO CA, page b40 XP000196659 Y. ZHANG ET AL.: "Isolation and characterization of human type 5 17-beta-hydroxysteroid dehydrogenase"	1-15,25, 26
A	see the whole document	16-24, 27-34
X	EMBL SEQUENCE DATABASE, Acc.No.: Emhum1:Hsorf1,15 December 1993, N. Miyajima, "Human mRNA (HA1753)". see abstract XP002020808	1,2, 12-15
A		3-11, 16-24, 27-34

☒ Further documents are listed in the continuation of box C.

☐ Patent family members are listed in annex.

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- \*O\* document referring to an oral disclosure, use, exhibition or other means
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- \*&\* document member of the same patent family

Date of the actual completion of the international search

12 December 1996

Date of mailing of the international search report

06.01.97

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Authorized officer

De Kok, A

## INTERNATIONAL SEARCH REPORT

International Application No

PCT/CA 96/00605

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JOURNAL OF STEROID BIOCHEMISTRY AND MOLECULAR BIOLOGY, vol. 46, 1993, OXFORD GB, pages 673-679, XP000196680 K.N. QIN ET AL.: "Molecular cloning of multiple cDNAs encoding human enzymes structurally related to 3-alpha-hydroxysteroid dehydrogenase"	1,2, 12-15
A	see the whole document	3-11, 16-24, 27-34
A	--- JOURNAL OF STEROID BIOCHEMISTRY AND MOLECULAR BIOLOGY, vol. 55, no. 5-6, 1995, OXFORD GB, pages 581-587, XP000196678 V. LUU-THE ET AL.: "Characterisitics of human types 1, 2 and 3 17-beta-hydroxysteroid dehydrogenase activities" see the whole document	3-11, 27-29
A	--- JOURNAL OF STEROID BIOCHEMISTRY, vol. 34, no. 1-6, 1989, OXFORD GB, pages 189-197, XP000196658 F. LABRIE ET AL.: "Characterization of two mRNA species encoding human estradiol 17 beta-dehydrogenase and assignment of the gene to chromosome 17" see the whole document	1-15
A	--- JOURNAL OF STEROID BIOCHEMISTRY AND MOLECULAR BIOLOGY, vol. 41, no. 3-8, March 1992, OXFORD GB, pages 605-608, XP000196681 M. DUMONT ET AL.: "Expression of human 17 beta-hydroxysteroid dehydrogenase in mammalian cells" see the whole document	1-11
A	--- EUROPEAN JOURNAL OF BIOCHEMISTRY, vol. 209, no. 1, 1992, BERLIN DE, pages 459-466, XP000196661 H. PELTOKETO ET AL.: "Genomic organisation and DNA sequences of human 17-beta hydroxysteroid dehydrogenase genes and flanking regions" see the whole document --- -/--	1,25,26

# INTERNATIONAL SEARCH REPORT

International Application No  
PCT/CA 96/00605

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JOURNAL OF STEROID BIOCHEMISTRY AND MOLECULAR BIOLOGY, vol. 53, no. 1-6, 1995, OXFORD GB, pages 37-39, XP000196679 S. ANDERSSON ET AL.: "The molecular biology of androgenic 17-beta-hydroxysteroid dehydrogenases" see the whole document ---	1,25,26
A	JOURNAL OF THE NATIONAL CANCER INSTITUTE, vol. 81, no. 20, 18 October 1989, BETHESDA US, pages 39-44, XP000351436 M. ROTHENBERG ET AL.: "Oligodeoxynucleotides as anti-sense inhibitors of gene expression: therapeutic implications" see the whole document ---	16-24
P,X	EMBL SEQUENCE DATABASE, Acc. No.: Emhum1:Hs516761, 19 April 1996, P.J. Ciaccio et al., "Human dihydrodiol dehydrogenase gene, 5'-flanking region" XP002020809 see abstract -----	26,32,33